

Universal Design of Behind-the-Counter Workspaces

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by

Gourab Kar

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Universal Design of Behind-the-Counter Workspaces

Approved by:

Professor Abir Mullick
School of Industrial Design
Georgia Institute of Technology

Karen Milchus
Center for Assistive Technology and Environmental Access
Georgia Institute of Technology

Professor Kevin Shankwiler
School of Industrial Design
Georgia Institute of Technology

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Summary

This project is a part of CATEA's Workplace Accommodations grant and adopts a human-centered design methodology to research, develop, test and evaluate new designs of behind-the-counter workspaces that maximize independence and participation of employees, and increase their employment possibilities.

Preliminary research shows that current designs of behind-the-counter workspaces do not accommodate needs of intended employees including seated and standing users. According to research, factors like task design and lack of environmental fit have contributed to job loss and reduced employment. Further more, current designs of counters do not enable people with disabilities and older adults to work in these environments. Through participatory research techniques and ergonomic studies, this project identified accessibility and usability needs and outlined basic and extended design guidelines for behind-the-counter workspaces that would address these needs. Results from the environmental research, usability studies and precedent studies were analysed to create design specifications for a new range of behind-the-counter workspaces. The resulting workspace designs incorporate the principles of universal design and aim to expand employment opportunities for people with disabilities and older adults.

Chapter 1: Introduction

This thesis project examines the usability and accessibility of workplaces as it applies to behind-the-counter jobs for people with and without disabilities. It is a project within CATEA's Rehabilitation Engineering Research Center on Workplace Accommodations (Work RERC). That grant focuses on development of new designs for workstations in environments where accessible workstations are not available. Prior to this project, preliminary studies looked at different behind-the-counter workspaces and identified barriers to employment for older adults and people with disabilities in these environments. The studies illustrated commonalities and differences in these professional environments considering work layout, body posture, technologies and spatial design. This project studies five of these professional workspaces in depth, with the aim of creating a common solution that brings economies of scale into the universal design argument, and makes it a more viable business proposition.

Through participatory research techniques and ergonomic studies, this project identified environmental and usability needs and outlined design guidelines of a modular workstation design that would address these needs. Based on these guidelines and examining possible future customer service scenarios influenced by new trends and emerging technologies, future behind-the-counter concepts were developed. These concepts try to address the need for wider accessibility and better interactions, while adding value through design that aims to increase job opportunities for people with disabilities provide a better experience for the end users and maximize store investment efficiency of front-end equipment. Thus, there is are social, legal, ethical and economic arguments for incorporating such solutions in contemporary workspaces.

Chapter 2: Overview

A human-centered design methodology involving research, development, testing and evaluation was adopted for this research. The sequence is as follows:

- **Literature Reviews** - Current literature on disability and work was studied
- **Objectives** - Primary objectives of this research were established
- **Research Questions** - Appropriate research questions were developed
- **Environmental Study** - Role of physical environment in work was studied
- **Usability Study** - How people work in behind-the-counter workspaces studied
- **Precedent Analysis** - Contemporary design solutions were analysed
- **Design Thinking** - Findings of research synthesized into design specifications
- **Design Development** - Specifications were developed into design concepts
- **Scale Models** - Design concepts were prototyped into scale models
- **Final Design** - CAD models and photorealistic renderings were developed
- **Feedback** - User were shown models and renderings to elicit responses
- **Evaluation** - New designs were evaluated with a Universal Design Checklist
- **Conclusion** - Findings of research presented and future roadmap developed

Chapter 3: Literature Reviews

The literature review was conducted using a variety of sources, including electronic databases like Pubmed, ScienceDirect, Ergonomics and Compendex. Georgia Tech library books on human factors, workspace design, ergonomics, were consulted as well. Google searches with keywords like “workspace ergonomics”, “disability+work”, “workstation design”, “musculoskeletal disorders” revealed data relevant to the project. These include:

- Environmental Design and Work
- Occupational Health Data
- Work and Disability Data
- Universal Design Principles
- Americans with Disabilities Act

Environmental Design and Work:

Research on relation between environmental design and work performance in behind-the-counter workspaces is fragmented and lacks a coherent, unified approach. While there has been considerable research on office workspaces and seating solutions (in response to high incidences of work related musculoskeletal disorders and their propensity to result in long term disabling conditions), work in behind-the-counter workspaces has not been researched to the same level of detail.

Recognising the vast range of professions which feature work behind-the-counter and the finite time and resources of a graduate thesis, the focus was on five specific professions which had been identified in a preceding research study. These professions, while being separate workspaces in isolation, were representative of behind-the-counter work and had commonalities in spatial and temporal aspects.

The five environments shortlisted were: Library Counters, Hotel Receptions, Airline Check-in Counters, Office Receptions and Registration Counters. All the above environments featured a mix of stationary and mobile work in sedentary and standing postures with over-the-counter interaction with customers, employees or students within in a public setting. Review of occupational health literature on these specific workspaces revealed certain patterns and trends between environmental design and work related stress. The following pages highlight some of the significant findings of the literature review:

Library Counter Work:

A survey of library circulation desk employees in Quebec, Canada revealed high incidence of symptoms of MSDs in a sample of 406 respondents, 90% of whom had experienced symptoms during the previous year [1]. Of these employees, 80% associated their musculoskeletal symptoms with their workplace, 67% had consulted a health professional and 29% had needed to take time off work because of the symptoms. The back was the main area affected (68% of respondents), followed by the upper limbs (64%) and the neck area (54%). Some 45% of respondents identified problems in the lower limbs. Tasks identified as likely to cause MSDs among employees included working with video display terminals, repetitive manual handling tasks and working in one position for long periods. When their results were compared with data on other kinds of work, different authors found that the incidence of pain experienced in the lumbar region, shoulders, wrists, neck and feet was more significant among library employees than among other office workers.

Hotel Reception Work:

While specific data for hotel reception work was not available, significant research on occupational health of hotel workers performing a wide variety of

hospitality work was available. In the United States, hotel workers are nearly 40% more likely to be injured on the job than all other service sector workers [2]. Hotel workers also sustain more severe injuries resulting in more days off work, more job transfers, and more medically restricted work compared to other employees in the hospitality industry [3]. A survey of house keeping staff in Las Vegas, Nevada revealed work related pain was experienced by 75% of respondents during the past 12 months. Almost all (94%) said the pain began during their current job, 61% had visited a doctor for this pain, and 57% said they used sick or vacation time for this pain. Thirty-one percent reported this work related pain to management. Additionally, 73% took pain medication during the past 4 weeks for "pain they had at work"[4].

Airport Check-In Work:

A study by International Labor Organization (ILO) revealed that musculoskeletal problems were common among airport check-in workers and could lead to temporary or permanent disability [5]. Among the respondents more than 70% indicated that neck pain affected work performance, and nearly 16% reported temporarily leaving their professional activity because of neck pain. Reporting of symptoms was subjectively based on the feelings and perceptions of the workers. The significant number of workers reporting living with MSD pain compared with the relatively low number of lost work days due to injury or pain (results obtained by combination of questionnaire, interview and official lost work time reports) indicates that many check-in workers consider musculoskeletal pain to simply be "part of the job."

MSDs are prevalent and severe among airport check-in workers and may lead to temporary or permanent disability. An important number of workers live with pain from musculoskeletal disorders in various parts of the body. Some workers have lost work time due to pain or disability, many check-in workers experience pain that interferes with their job performance, while many perform their job functions

despite living with significant pain. The awkward twisting and bending involved in baggage tagging also appears to cause MSDs.

Office Reception Work:

While MSDs have traditionally been associated with physically strenuous or intensive occupations, there is increasing evidence that sedentary office work and other work requiring constrained sitting or standing postures are associated with a high incidence of MSD [6,7]. Research suggests that office based work that requires frequent access to and interaction with Visual Display Units (VDUs) has potential for incompatibility between the human element and demands of modern technology, and that enhanced compatibility and interaction between these two elements are required for the risk of MSD to be minimised [8]. Risk factors relating to MSD development amongst VDU operators have been identified to relate to both physical [9,10,11] and psychosocial factors [12,13,14].

Occupational Health Data

In 2008, sprain or strain injuries accounted for 39 percent of total injury and illness cases requiring days away from work. Soreness and pain (including the back) accounted for 11 percent of total cases [15]. Forty-five percent of sprains or strains were the result of overexertion. Design of workspaces that reduce such overexertion may contribute to lowering such incidences. Bodily reaction (such as bending, reaching, twisting, or slipping without falling) accounted for another 22 percent and 11 percent were the result of falls on the same level. Allowing for work surfaces that eliminate need for bending or twisting should also be explored. In 40 percent of the sprain and strain cases, the back was injured. Twenty-three percent of sprains and strains occurred to workers in service occupations. Musculoskeletal disorders (MSDs), often referred to as ergonomic injuries,

accounted for 29 percent of all workplace injuries and illnesses requiring time away from work in 2008 [16]. There were 317,440 MSDs in 2008 requiring a median of 10 days away from work. The pie charts given below provide further information on sprains and strains by exposure type and by parts of the body. Designs for behind-the-counter workspaces that reduce overexertion and eliminate factors contributing to MSD will positively have an impact on work life, increase workforce productivity and provide a financial basis for investment in better designs.

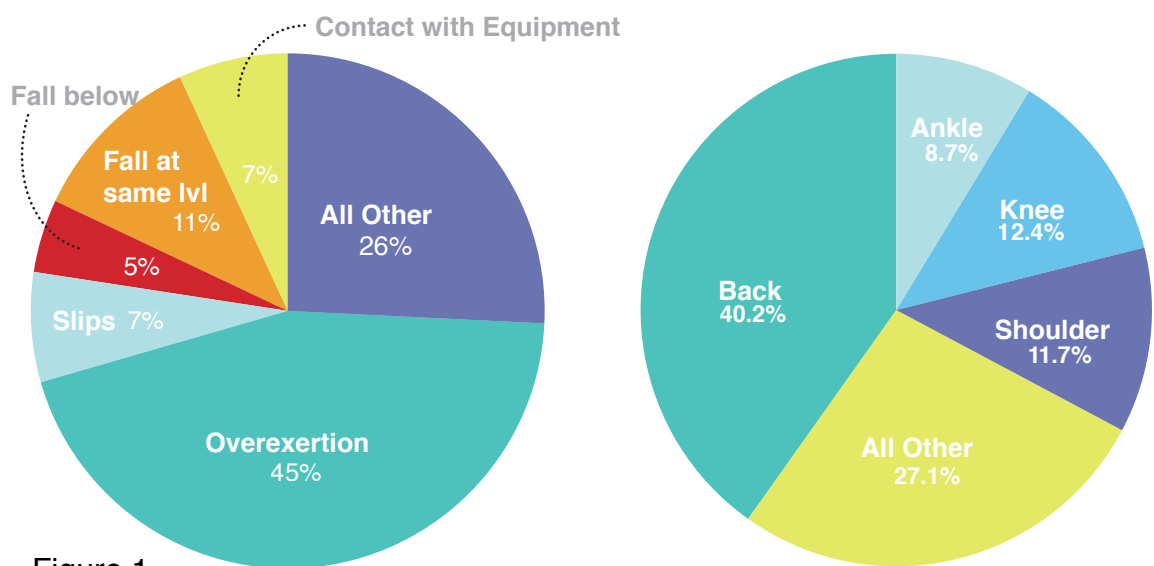


Figure 1
Strains and sprains by event and by part of the body, 2008
 Bureau of Labor Statistics, US Department of Labor

Work and Disability

Prevalence of disability among working age people:

According to the Survey of Income and Program Participation (SIPP), 32.1 million working age people (or 18.7% of the population ages 18 to 64) have a disability as defined under the provisions of the Americans with Disabilities Act [17]. The SIPP definition includes people who have reported being limited or unable to work as well as those who have qualified for a Social Security program based on

inability to work. This includes people who use wheelchairs, report functional limitations or have other specified conditions, but may be fully employed and report no limitation in the amount or kind of work. Using the SIPP definitions 18.7% of the working age population 18-64 years (32.1 million) report a disability. Of these, severe disabilities were reported by 8.7% (14.9 million); non severe disabilities account for the other 10% (17.2 million). The fact that almost a fifth of the US working population has a disability should be a cause for concern and the adoption of universal design principles to create accessible and equitable work spaces would go a long way in mitigating the social and financial disparities.

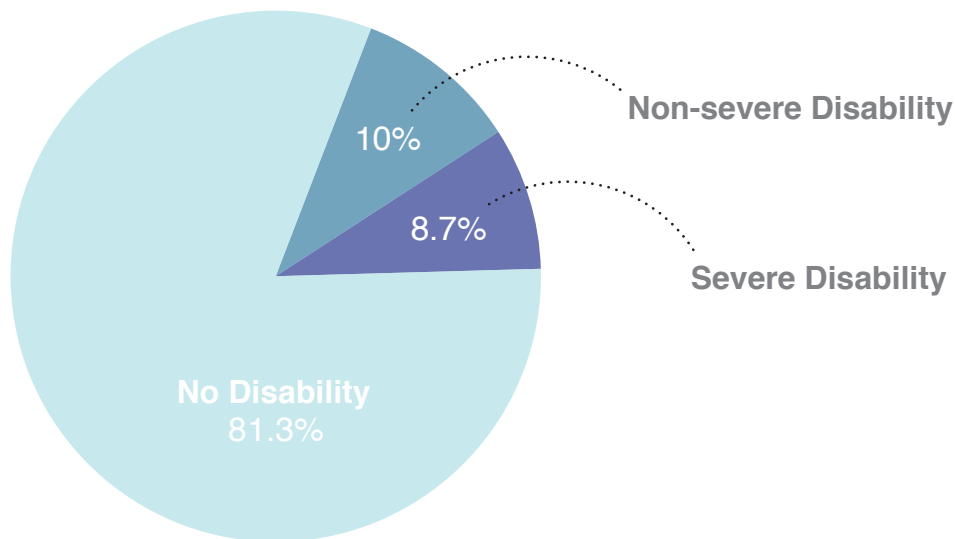


Figure 2
Disability status of non-institutionalized populations, 18-64 years
InfoUse Report, National Institute on Disability and Rehabilitation Research

Employment status for people with different disabilities: Among people with no disability, 82.1% are employed. Of those with mental disabilities, 41.3% are employed [18]. The percentage is even lower for people with mobility impairments, including those using a cane, crutches, walker (27.5%) or a wheelchair (22%). Among people with functional limitations, 32.2% are employed. There is great variation in employment, depending on the type of limitation, with lower rates in mobility related impairments. The graphs for percentage of people employed by disability status as well as by functional limitation is shown below. The fact that only 22% of wheelchair users are employed means that designs of

workspaces need to shift from the current top down legislation driven model to a bottom-up design driven approach that incorporates universal design principles to create accessible and enabling workspaces for people with disabilities.

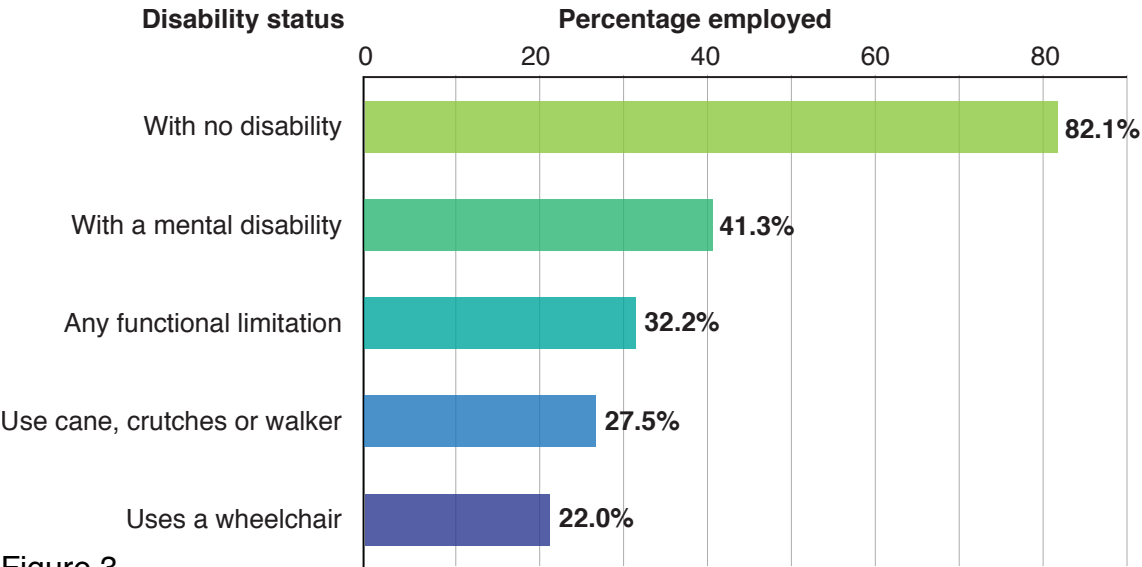


Figure 3
Percentage employed by disability status
InfoUse Report, National Institute on Disability and Rehabilitation Research

Health conditions causing work limitations: The National Health Interview Survey (NIHS) provides information about which chronic health conditions most frequently cause work limitation [19]. Back disorders are the most frequent cause of work limitation among people 18-64 years old. Its is estimated that almost 4 million people experience work limitations that are primarily caused by back disorders, representing 21.1% of all main conditions. Designing behind-the - counter workspaces that lower the risk of work related back injuries and enable employees to work productively will have a positive impact on employee satisfaction and lower occupation health related expenditure incurred by the employer. The research should focus on identifying reasons of back injuries at work and provide design solutions that eliminate or reduce such occurrences.

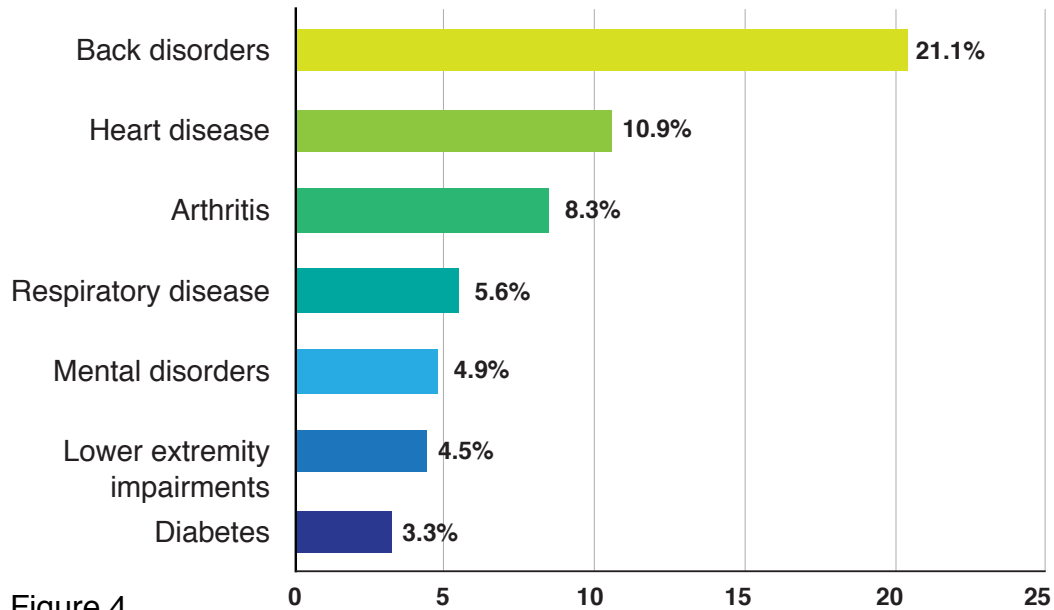


Figure 4
Percentage of people whose work limitation is caused by condition
 National Health Interview Survey, 1996. InfoUse Project, NIDRR

Universal Design

The Principles of Universal Design:

Universal Design has been defined as - *The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design* [20]. The next page gives a brief overview of the Principles of Universal Design. These principles are presented in the following format: name of the principle (*intended to be a concise and easily remembered statement of the key concept embodied in the principle*); definition of the principle, (*a brief description of the principle's primary directive for design*); and guidelines, (*a list of the key elements that should be present in a design which adheres to the principle*). These principles offer designers guidance to better integrate features that satisfy the needs of as many users as possible. They are intended to guide the design process, allow systematic evaluation of existing designs and assist in educating both designers and consumers about characteristics of more usable products and environments.

Table 1

The Principles of Universal Design

PRINCIPLE ONE: Equitable Use

The design is useful and marketable to people with diverse abilities.

- 1a. Provide the same means of use for all users.
- 1b. Avoid segregating or stigmatizing any users.
- 1c. Provisions for privacy, security, and safety for all users.
- 1d. Make the design appealing to all users.

PRINCIPLE TWO: Flexibility in Use

The design accommodates a wide range of individual preferences and abilities.

- 2a. Provide choice in methods of use.
- 2b. Accommodate right- or left-handed access and use.
- 2c. Facilitate the user's accuracy and precision.
- 2d. Provide adaptability to the user's pace.

PRINCIPLE THREE: Simple and Intuitive Use

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

- 3a. Eliminate unnecessary complexity.
- 3b. Be consistent with user expectations and intuition.
- 3c. Accommodate a wide range of literacy and language skills.
- 3d. Arrange information consistent with its importance.
- 3e. Provide effective prompting and feedback during and after task completion.

PRINCIPLE FOUR: Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

- 4a. Use different modes (pictorial, verbal, tactile) for presentation of essential information.
- 4b. Provide adequate contrast between essential information and its surroundings.
- 4c. Maximize "legibility" of essential information.
- 4d. Differentiate elements in ways that can be described easily.
- 4e. Provide compatibility with a variety of techniques or devices used by people.

PRINCIPLE FIVE: Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

- 5a. Arrange elements to minimize hazards and errors.
- 5b. Provide warnings of hazards and errors.
- 5c. Provide fail safe features.
- 5d. Discourage unconscious action in tasks that require vigilance.

PRINCIPLE SIX: Low Physical Effort

The design can be used efficiently and comfortably and with a minimum of fatigue.

- 6a. Allow user to maintain a neutral body position.
- 6b. Use reasonable operating forces.
- 6c. Minimize repetitive actions.
- 6d. Minimize sustained physical effort.

PRINCIPLE SEVEN: Size and Space for Approach and Use

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

- 7a. Provide a clear line of sight to important elements for any seated or standing user.
- 7b. Make reach to all components comfortable for any seated or standing user.
- 7c. Accommodate variations in hand and grip size.
- 7d. Provide adequate space for the use of assistive devices or personal assistance.

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The Rationale for Universal Design:

The challenge of designing for the whole population is just not a matter of social urgency – it has become one of the defining business priorities of this age [21].

We are now living in a world of rapidly aging populations, with a broader range of physical and cognitive capabilities than ever before. Allied to this are new and emerging technologies that are contributing to new patterns in living and working. The need has never been greater for products, services and environments to be developed in such a way that do not exclude – rather, reflect more accurately the diverse demands of today's users – particularly the needs of an increasingly graying demographic. That is why economies and governments around the world are now recognizing the importance of the movement called Universal Design. The challenge of universal design is not just about offering equality in social opportunity. There are significant ethical, legal and business implications for the adoption of an inclusive framework to the design of products, services and environments. Let us look into some of the ethical, legal and business implications of universal design in the context of a rapidly aging populace.

The Ethical Argument: The global trend of increasing life expectancy coupled with lower of birth rates in the decades since World War II has resulted in a marked demographic change to an aged population in developed countries. As the baby boomers approach retirement age, they will confront environments, products and services that are not taking due consideration of their physical and cognitive abilities. There is an increasing sense of disenfranchisement among the elderly and disabled, when it comes to employment opportunities in the service sector.

As an egalitarian society, it is a moral imperative to create opportunities for disabled people to contribute productively to society. This project aims to incorporate recent research findings of declining physical, sensory and cognitive abilities of older adults and individuals with disabilities, and design workspaces that are built with their abilities in mind.

The Legal Argument: Governments around the world are responding to ethical arguments of universal design in favour of greater social inclusion facilitated by appropriate inclusive design of products, services and environments with new legislation. The Americans for Disability Act.1990 (US) and the Disability Discrimination Act.1995 (UK) were one of the first examples of universal design practices mandated by governments. Both 'carrot' and 'stick' policies adopted for complying with legislation have given rise to a range of product, services and environments that are built with the capabilities of the user in mind.

The Business Argument: Adoption of inclusive design features is not just for the benefit of customers. Employers will find themselves having to increasingly consider making their workplaces more accessible and inclusive. The concept of workplace accessibility is typically associated with building design and wheelchair access in particular. However, that represents only a small number of issues needing to be addressed to make a truly accessible workplace. An accessible workplace requires not only that the employees can get to and from their work-place, but also that they can interact with the tools and equipment necessary for productivity. In designing behind-the-counter workspaces, the goal is to identify possible disabling conditions created by both environment and equipment design and build a new range of workspaces that enable safe, efficient and effective work for people with a wide range of physical and cognitive abilities. As the baby boomers move into their sunset years they create a large, relatively underserved market of older people with significant disposable income. Adopting inclusive design practices will expand the market, enable early adopters to gain a competitive edge, also enabling greater share of the government projects that legislate inclusiveness in business. Given the global demographic trends over the next few decades, it is imperative for business to realize the implications for design in an increasingly aging populace and align themselves with the new realities.

ADA and Work

Employment rights under ADA:

The Americans with Disabilities Act (ADA) is civil rights legislation that covers people with disabilities in a variety of settings [22]. Title I of the ADA deals with employment and says that - *a qualified person with a disability is entitled to equal employment opportunities*. It recognizes that reasonable accommodations, such as a modified workstation, may be needed to enable the person to perform the job. These accommodations are to be determined on a case-by-case basis.

Reasonable accommodation is any change or adjustment to a job or work environment that permits a qualified applicant or employee with a disability to participate in the job application process, to perform the essential functions of a job, or to enjoy benefits and privileges of employment equal to those enjoyed by employees without disabilities. For example, reasonable accommodation may include: (1) providing or modifying equipment or devices, (2) job restructuring, (3) part-time or modified work schedules, (4) reassignment to a vacant position, (4) adjusting or modifying examinations, training materials, or policies, (5) providing readers and interpreters, and (6) making the workplace readily accessible to and usable by people with disabilities.

An employer is required to provide a reasonable accommodation to a qualified applicant or employee with a disability unless the employer can show that the accommodation would be an undue hardship -- that is, that it would require significant difficulty or expense. This provision of providing reasonable accommodation for work forms the ethical and legal basis of our research. The idea is to understand the challenges of behind-the-counter work for individuals with disabilities in particular as well as the general working age population, and then design a modular range of workspaces that provide reasonable work accommodations for the users while ensuring a sustainable business model for corporations investing in the design, manufacturing and distribution.

From Assistive Technology to Universal Design:

The current approach to workplace accommodations follows the assistive technology (AT) model which, while delivering solutions to individual users, is difficult to scale up and create economies of scale that lead to sustainable business practices [20]. Although specialized designs are important to support the employment of people with disabilities, success in AT manufacturing is determined not just by engineering, but by selling significant volumes of the product to enable a company to justify production and generate sufficient sales revenues. Small market size and low consumer demand make these specialized accommodations difficult to obtain, maintain, and repair. Moreover, their institutional or “home-made” look greatly lowers demand, and many do not interface well with the surrounding environment or with other products and technologies. Not surprisingly, it is not uncommon among users with disabilities to abandon assistive devices, even though they are designed for their use. As a result, economics and market forces are causing many AT companies to look at incorporating additional features into their products to expand their market base.

Similarly, product designers realize that these specialized designs present opportunities to develop integrated universal solutions that will work for people with and without disabilities and incorporate specialized designs into mass-produced and marketed workspaces [20]. By employing principles of flexibility, adjustability and interchangeability, as well as simplifying construction, optimizing production, and improving appearance, designers can develop universal design products that provide supportive benefits of assistive design to everyone.

ADAAG:

Title III of the ADA deals with Public Accommodations, or places that a person with a disability might visit as a customer, such as hotels, libraries, or airports [23]. The ADA Accessibility Guidelines (ADAAG) are part of this section and the relevant section dealing with sales and service counters and check-out counters

are relevant to our research. The ADAAG generally focus on basic access for people with motor impairments and there are few guidelines that deal with sensory or cognitive issues. While this project is primarily about creating work accommodations for behind-the-counter environments, issues of accessibility to the workspace, especially in context of the public nature of these environments is an important consideration. The current ADAAG, 2002 has detailed guidelines about check out counters in business, mercantile and civil spaces and those recommendations are given below.

Sales and Service Counters, Teller Windows, Information Counters:

(1) In areas used for transactions where counters have cash registers and are provided for sales or distribution of goods or services to the public, at least one of each type shall have a portion of the counter which is at least 36 in (915mm) in length with a maximum height of 36 in (915 mm) above the finish floor. It shall be on an accessible route. Such counters shall include, but are not limited to, counters in retail stores, and distribution centers. The accessible counters must be dispersed throughout the building or facility. In alterations where it is technically infeasible to provide an accessible counter, an auxiliary counter meeting these requirements may be provided.

(2) In areas used for transactions that may not have a cash register but at which goods or services are sold or distributed including, but not limited to, ticketing counters, teller stations, registration counters in transient lodging facilities, information counters, box office counters and library check-out areas, either:

(i) a portion of the main counter which is a minimum of 36 in (915 mm) in length shall be provided with a maximum height of 36 in (915 mm); or (ii) an auxiliary counter with a maximum height of 36 in (915 mm) in close proximity to the main counter shall be provided; or (iii) equivalent facilitation shall be provided (e.g., at a hotel registration counter, equivalent facilitation might consist of: (1) provision of a folding shelf attached to the main counter on which an individual with a

disability can write, and (2) use of the space on the side of the counter or at the concierge desk, for handing materials back and forth). All accessible sales and service counters shall be on an accessible route.

Check-out Aisles:

In new construction, accessible check-out aisles shall be provided in conformance with the following guidelines : For total check-out counters ranging from (1-4), (5-8), (9-15) and over 15; the minimum number of accessible counters have to be 1, 2, 3 and 3 plus 20% of additional aisles respectively. Clear aisle width for accessible check-out aisles shall comply with minimum wheelchair access standards and maximum adjoining counter height shall not exceed 38 in (965 mm) above the finish floor. The top of the lip shall not exceed 40 in (1015 mm) above the finish floor. Signage identifying accessible check-out aisles shall comply with international accessibility standards and shall be mounted above the check-out aisle in the same location where the check-out number or type of check-out is displayed.

While these are minimum standards that are legally enforceable, our approach to the issue of equitable access is more universal and aims for a degree of flexibility using a modular design that will cater to the needs of a broad range of users in a democratic, non-discriminatory way. By adopting an user-centered approach we will observe and interview people at work in behind-the-counter workspaces, analyse the problems and challenges in these workspaces, conceptualise new designs of workspaces and build prototypes of modular workspaces that are safe, efficient and enabling environments for work.

Chapter 4: Objectives

The primary objective of this project was to understand work in behind-the-counter environments as the interaction between human abilities, technologies and environmental design. Conventionally, the design of counters in different workspaces involves creating customised solutions for specific environments using off-the-shelf components from office workstation hardware. Accessibility regulations of the ADAAG for counter design in public spaces [23] have resulted in creation of a minimum number of accessible counters which do adhere to required standards but are a long way off from being truly inclusive to needs of the whole population. While there has been considerable human factors research on office workspaces, the aspect of behind-the-counter design has not been actively studied so far. The facts that (a) *work in retail spaces is among the top five professions in terms of injuries leading to days-away-from-work* [24], (b) *proportion of older adults in the workforce is projected to increase to 20% by 2025* [25] and that (c) *incidence of work related injuries increase with age (15.4% for people between 55-64 years of age)* [26] mean that the design of service environments in general, and behind-the-counter workspaces in particular have to be researched to understand the design challenges in creating workspaces for older adults and individuals with disabilities. The objectives of this research and the methodology adopted is outlined below.

1.) Study work requirements of five related workspaces: The hypothesis was that the nature of work in terms of customer interaction, workflow, body postures, technologies and work equipment were similar nature in all five workspaces studied, namely: library counters, hotel receptions, airport check-in, office receptions and event registration counters. To confirm this, observational research was conducted in all five environments to analyse work patterns and identify commonalities in usage, technologies and environmental design of spaces.

2.) Determine how current workspace design affects performance:

Ethnographic studies were conducted in five workspaces. Research methods included direct observation, contextual interviews, photo and video analysis to understand how current design of behind-the-counter workspaces impacts user performance for both staff and customers. Studies revealed user preferences, attitudes, common problems and work arounds; highlighted lack of '*environmental fit*' between human abilities and spatial environment [27], and generated design ideas for creating more inclusive solutions.

3.) Research problems associated with workspaces: Data from literature reviews corroborated our research which indicated a strong correlation between incidences of work injuries and environmental design of workspaces. The nature of work with long hours of sedentary postures or standing at the counter contributed to user fatigue and injuries of shoulder and lower back. Frequent bending and over extension to reach storage areas below the counter of or beyond the optimal reach envelope contributed to work related stress. Also, the profusion of peripheral digital devices for transactions contributed to inefficient workflow and greater cognitive demands on users.

4.) Understand commonalities in technologies: Research of the workspaces and technologies used, revealed commonalities in usage, spatial design and technologies. Identifying these common features helped arrive at a common set of design specifications for spatial needs and technologies.

5.) Design modular workspaces incorporating universal design: Once the common design specifications were established, various sets of permutations and combinations were explored to build the basic workstation module incorporating the principles of universal design. Features that were specific to a particular work environment were designed as add-on components that could be attached to main module for the unique work requirements.

Chapter 5: Design Questions

At the outset of this project there were four broad questions about behind-the-counter workstation designs. These research questions focussed on a human-centered approach towards understanding the needs, preferences and desires of users in context of the spatial and temporal aspects of the customer-service workspaces. The idea was to analyse current problems and pre-empt future challenges of behind-the-counter work in context of rapidly evolving technologies and an increasingly aging workforce. The four basic questions are:

- 1. How can there be a universal approach to designing behind-the-counter workspaces that through combination of parts allow customisation and produce environments best suited to perform a wide range of work?*

Considering the hypothesis that work in the five workspaces had broad commonalities along with some unique requirements, my interest was in knowing if and how there could be a universal approach to designing these workspaces. The idea being that a modular approach, incorporating the principles of universal design and leveraging flexibility offered by modularity would allow creation of environments suited to perform a wide range of work, while using the same kit of parts.

- 2. How can such designs meet the minimum and extended requirements of five different professions?*

Adopting a human-centered approach to design allowed study of the minimum and extended requirements of five different professions. The minimum requirements were based on commonalities observed in nature of work and were refined to create the common specifications for the modular design. The extended requirements reflect unique or specific work requirements of a specific profession and were designed as customisable elements that could add-on to the main module.

3. *How can environmental fit be carefully studied to bridge the existing gap between user needs and design outcomes?*

This research borrowed from theoretical idea of ‘*environmental fit*’ used to access human-environment relations in disability and rehabilitation research [27]. The environmental fit model provides a new approach to disability research in which the onus of the disability is manifested in the environment rather than the abilities of the individual. The role of the environment as a mediating variable recognises the powerful role environmental design plays in the social construction of disability. Such an approach can uncover how environmental design (both social and physical) can break down stereotypes and redefine disability itself. By redefining the environment as a disabling or enabling context for human performance, we were able to study the degree of environmental fit between user needs and current designs.

4. *How can these workspaces be customisable so people with and without disabilities can personalise them to meet their individual and collective needs?*

The idea of disability as envisaged in this research had three broad range of users - (a) users with pre-existing disabling conditions who were unable to work in these environments due to a lack of environmental fit, (b) users who were unable to work due to age related disabilities and (c) users who sustained occupational injuries which lead to a disability, causing them to go out of work. Other than these stakeholders, the user group also included people from the working population who would benefit from the universal design approach to design of behind-the-counter workspaces.

Chapter 6: Environmental Study

The environmental study looked at the role of physical environment in behind-the-counter work. It enabled a comprehensive understanding of how environmental design affects interaction of behind-the-counter staff, with technologies and customers. Five specific work-types, namely - library circulation counter, hotel check-in counters, airport check-in, office reception and registration counters were studied. These studies were conducted over a period of two months in fall 2009 in the Atlanta. User consent was obtained in writing before conducting the study and confidentiality of research data was strictly enforced.

Methodology

Each of the workspaces was observed for two separate days of the week, for hour-long sessions at two specific times of day - a) during the peak work period as reported by the users and b) during the lean work period between peaks. This sequence of observations enabled a fairly accurate representation of the range of tasks with peaks and troughs of activity over a typical work week. During the environmental study, notes were taken of the events and rough sketches made of the environments and activities. Still photographs were taken of instances that highlighted specific issues and had relevance to design. Due to requests from counter staff, no photographs were taken of customers across the counter. A measuring tape was also used to record basic dimensions of counter spaces and compare and contrast this data across all the five workspaces.

Subjects

The number of subjects studied varied according to the nature of activity and scale of the work facility. The library study featured the library circulation desk of a major research university in south-eastern United States. Four employees were at the counters during peak hours and two during non-peak hours. Hotel check-in counter had a provision for four employees behind the counter, but due to the downturn in the hospitality sector only two counters were used. The airport check-

in counter at the Hartsfield Jackson International Airport, Atlanta posed a problem of plenty. Given the multitude of check-in counters, the observational research was narrowed down to two check-in counters from one of the leading airlines, staffed by two check-in personnel. For the office reception, two separate receptions within the administrative offices of a major research university were the focus of the research. Each of the receptions was staffed by a receptionist. For registration counters, a temporary registration desk used for conference and workshop registrations within a conference facility was studied. This counter was operated by four staff members at its peak and by two members at non-peak hours.

Observations

The observational study made a spatial audit of each work environment, tabulating horizontal surfaces, vertical planes and storage areas and seating types associated with each workspace as well as an audit for devices and/or technologies used at work. Research also looked at the interaction between staff and customers across the counter and made detailed observations of movement patterns associated with work. The study laid emphasis on how accessible the current workspaces were regarding individuals with disabilities and older adults. In the beginning I did not anticipate certain environmental factors that also contribute significantly to work performance, but my informal interviews with users provided useful insights which led to important findings. Factors like ambient noise levels, localised heating and cooling, task lighting and glare, were high on the agenda for users and incorporated in our research. Once the field observations were complete, the information was compiled and annotated illustrations of the workspaces created to reveal the environmental design scheme. Also movement diagrams were created to show the human-environment interaction. The following pages provide examples of workspace design and movement patterns for each of the five work-types that were researched. Findings from this study are discussed in the end of this section.

Library Counter Design

The library circulation counter observed, is the main circulation desk for a major research university having more than 20,000 undergraduate and graduate students on its rolls. The circulation desk has four check-out counters and an accessible counter in compliance with ADAAG. The counters operate 24 x 7 from Monday to Friday, while remaining closed on Saturday and opening on Sunday afternoon. Staff have eight hour shifts which include working in the counter (check-in and check-out of books), re-shelving books and helping users with the library plotter placed alongside the circulation desk. Counters occupancy is based on workload and during peak hours all four counters are active with no defined counter for any staff. The images below show the physical design and movement patterns.

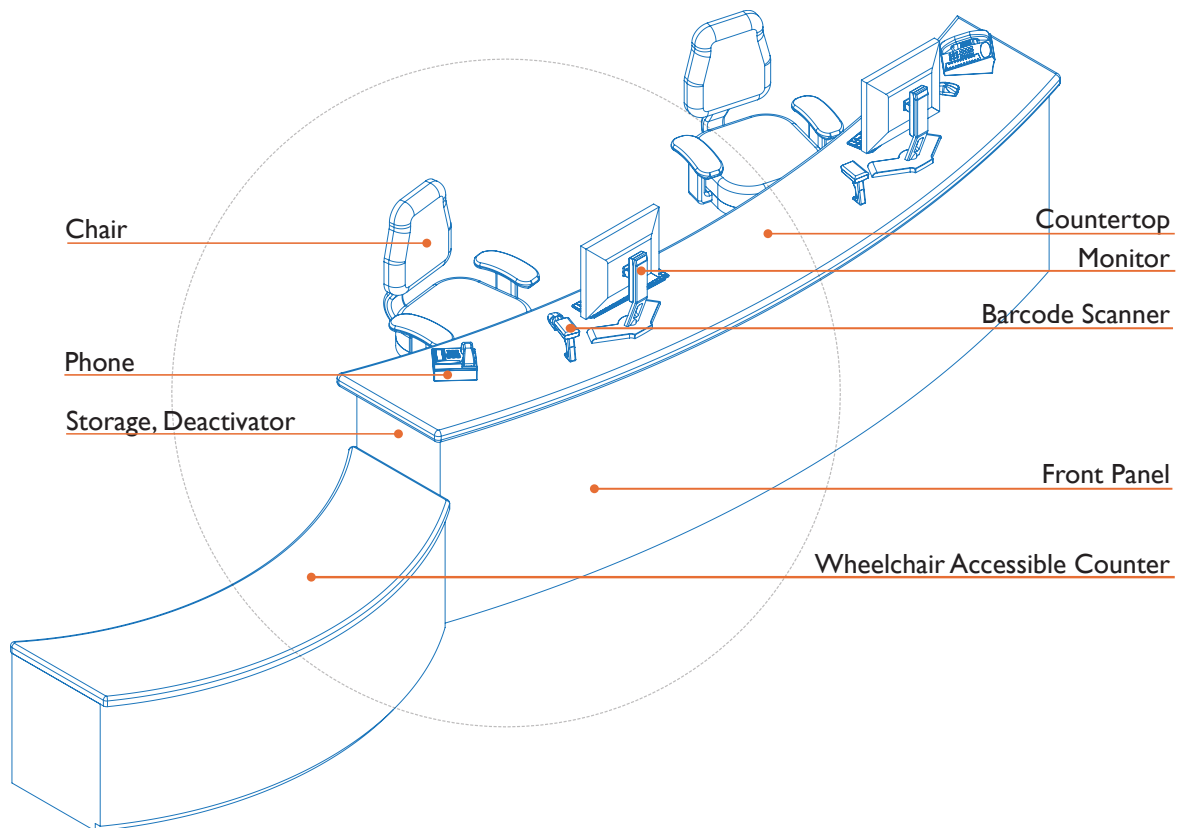


Figure 5
Library Circulation Counter
Environmental Audit and Devices

The range of movement for staff at counter extends to areas beyond the counter space. For books that are checked in, staff have to '*enter*' the data into the library circulation database using a bar-code scanner and return books to temporary storage shelves behind them. For checking-out books, staff have to '*mark*' them as checked-out using a bar-code scanner and desensitize them before any item can be lent out. The wheelchair accessible counter only allows for physical transactions which have to be validated with check-out procedures in one of the other counters. There were no wheelchair users to study actual usability of the accessible counter. The environmental study provided insights into challenges of library counter work and revealed opportunities for redesign of environment and work processes.

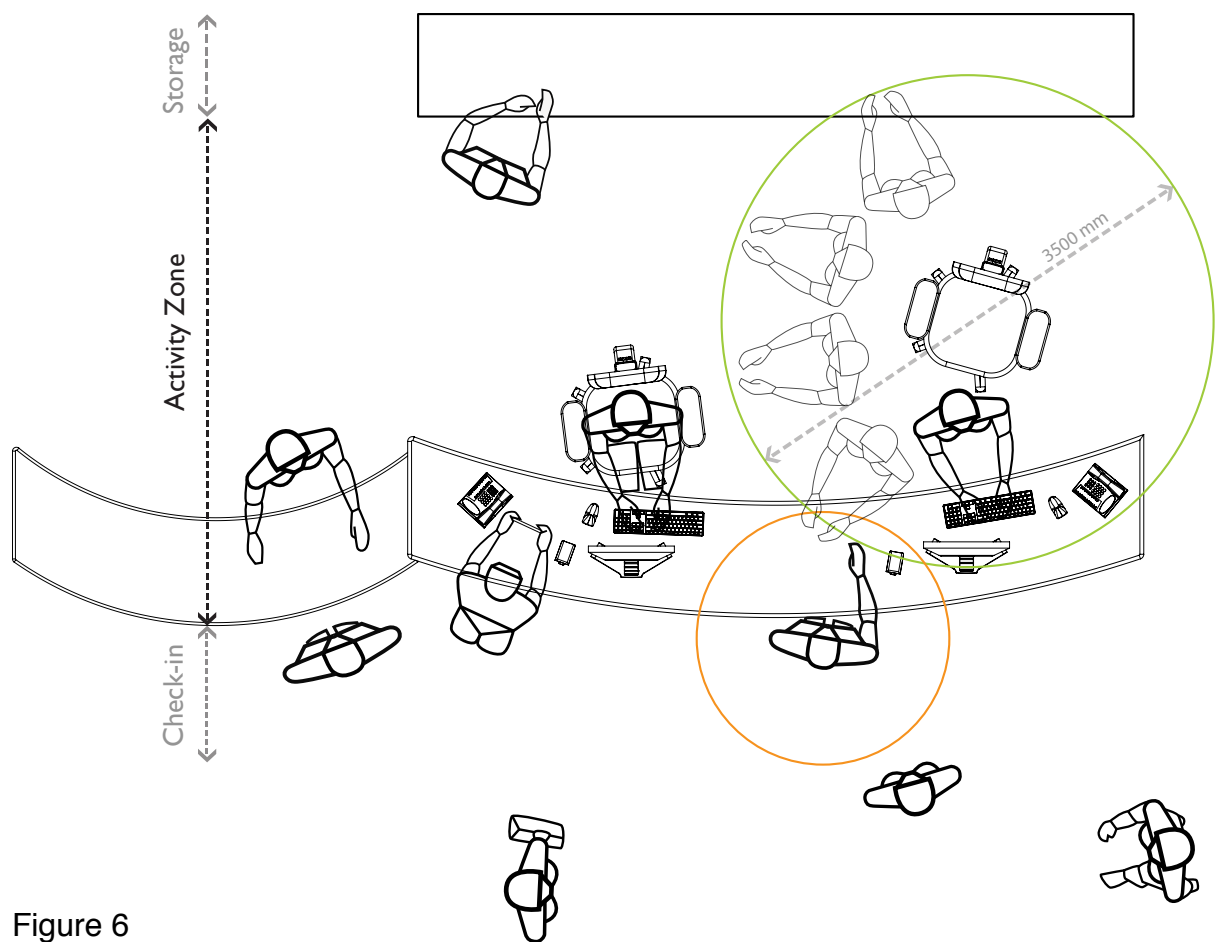


Figure 6
Library Circulation Counter
Movement Patterns for Staff and Students

Hotel Reception Counter

The hotel reception counter observed, was for a mid size hotel with 250 odd rooms located in the midtown Atlanta area. The reception desk had four check-out counters and an accessible ledge in compliance with ADAAG. The counters operate 24 x7, though most check-in and check-outs occur between 9:00 am to 1:00 pm during the day. Staff have eight hour shifts in which they perform the reception duties which include check-in and check-out processes for guests. Counter occupancy was based on workload and during peak hours all four counters were active with no defined counter space for any staff. The images below show the physical design and movement patterns.

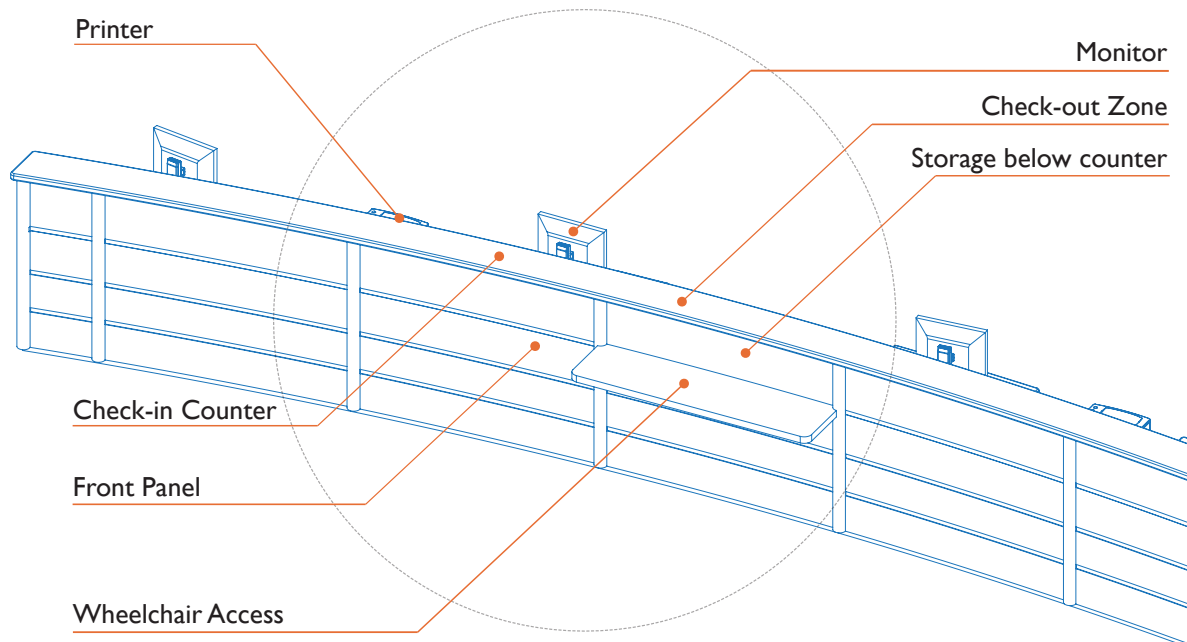


Figure 7
Hotel Check-in Counter
Environmental Audit and Devices

The reception desk had a split-level counter with staff working in a standing posture for the duration of a workday which could exceed 8 hours on occasions. A front ledge in the center, served as the wheelchair accessible counter. These designs reflect the conventional approach to inclusive access in which minimum standards are put into practice leaving a lot to be desired in terms of the enabling

possibilities of universal design. This example like many others highlights the narrow, code adhering approach to accessible design that is the norm in public environments. The adjoining image shows typical movement patterns in behind-the-counter work in hotel receptions. Staff attend to guests and process paperwork for check-in and check-out while standing at the counter. Frequent movements involve moving around the counter to access printer and document storage as well as bend down to access storage units below.

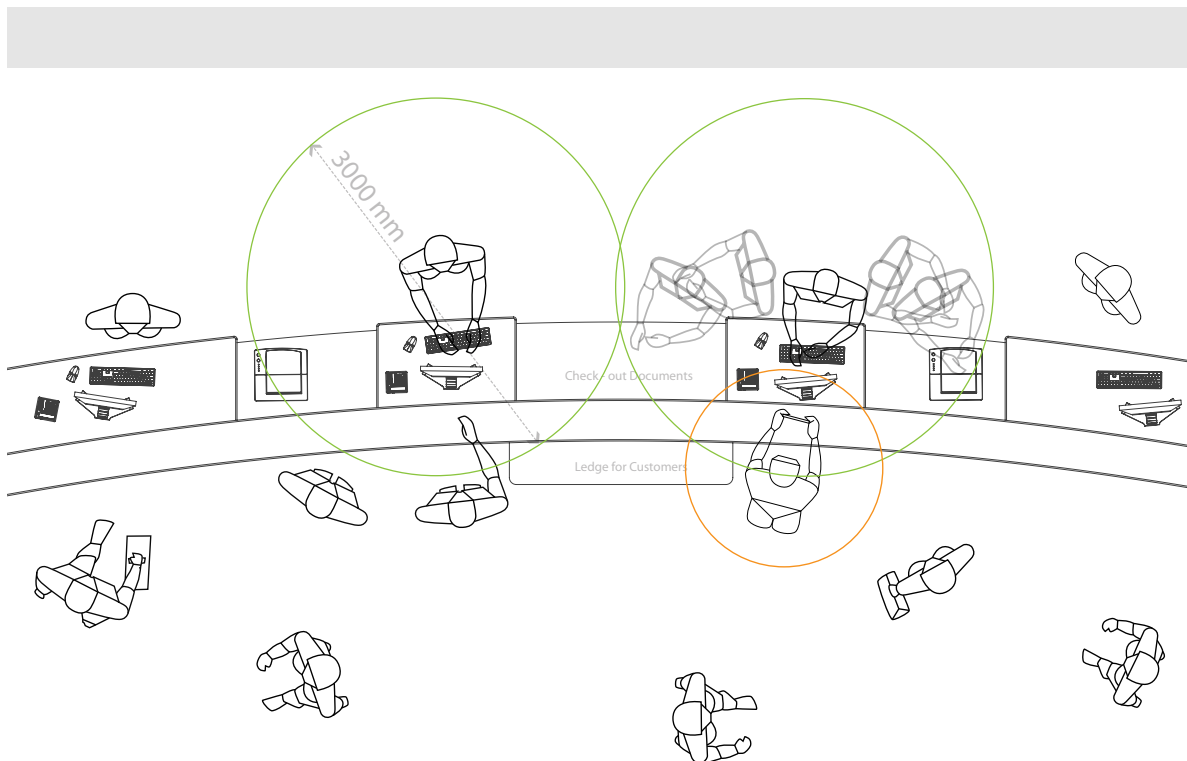


Figure 8
Hotel Check-in Counter
Movement Patterns for Staff and Guests

The environmental design study revealed insights about hotel reception work and the lack of environmental fit between user abilities and workspace design. The plethora of devices cluttering the user side of work space was a result of the mismatch between rise of digital technologies and the lack of a corresponding evolution of environmental design of workspaces. Informal interviews with counter staff revealed the need for chairs or minimal supports during long work hours

behind-the-counter. Analysis of the data from the environmental study helped create a set of design specifications from which a new modular design of behind-the-counter workspaces emerged.

Airport Check-in Counter

Airport check-in counters were observed at the Hartsfield-Jackson International Airport in Atlanta. Observations narrowed down to the check-in counters at the Delta Terminal. In a typical check-in scenario, staff stand behind counter and check passengers identity, provide the boarding pass, collect luggage and tag luggage then load them to the conveyor belt. The work is a combination of cognitive tasks (identity card check, processing ticket data, printing ticket and luggage tag) as well as physical tasks (attach tag, load the luggage on to a conveyor belt) and has high incidence of work related musculoskeletal disorders. The image below shows one of the check-in counters at the Delta Terminal.

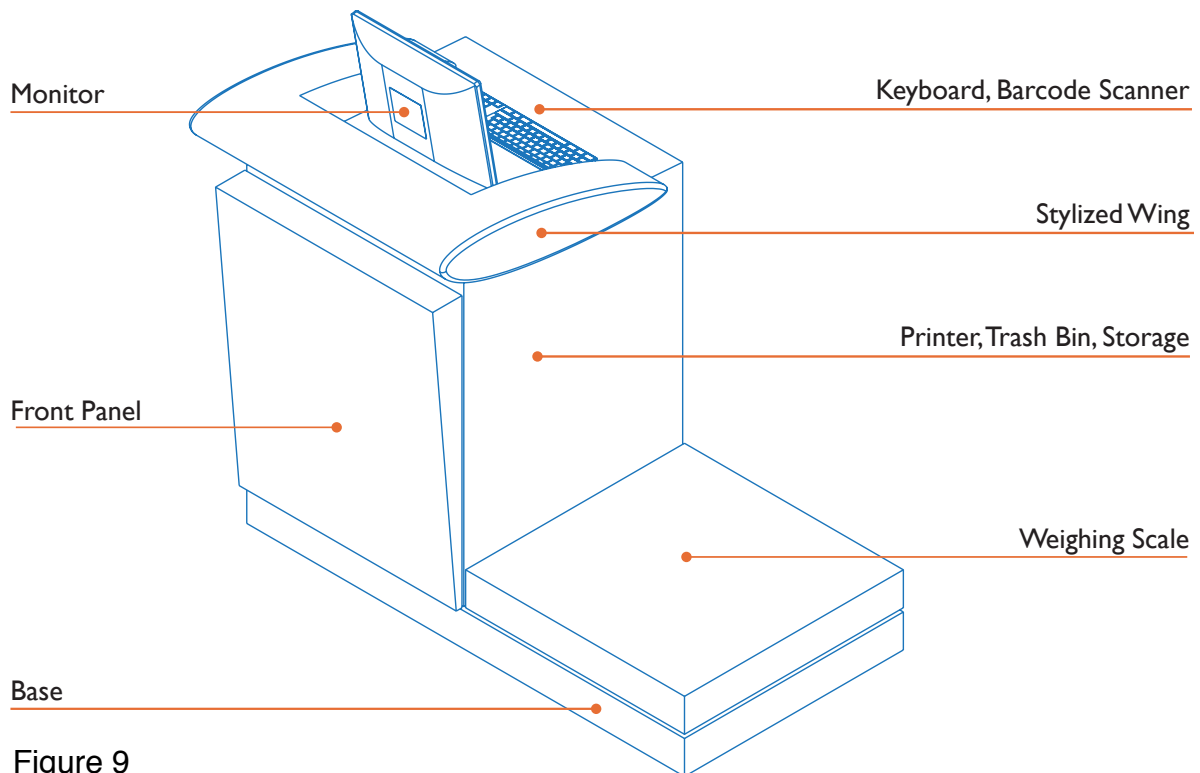


Figure 9
Airport Check-in Counter
Environmental Audit and Devices

Observational research into movement patterns highlighted inconsistencies in the environmental design that slowed down the check-in process and increased potential for occupational injuries. The high weighing scale, for example can be a cause of repetitive stress injuries for check-in staff due to frequent lifting of loads at work. Also, the counter shape can look beyond rectilinear configurations for better customer interaction and efficient workflow.

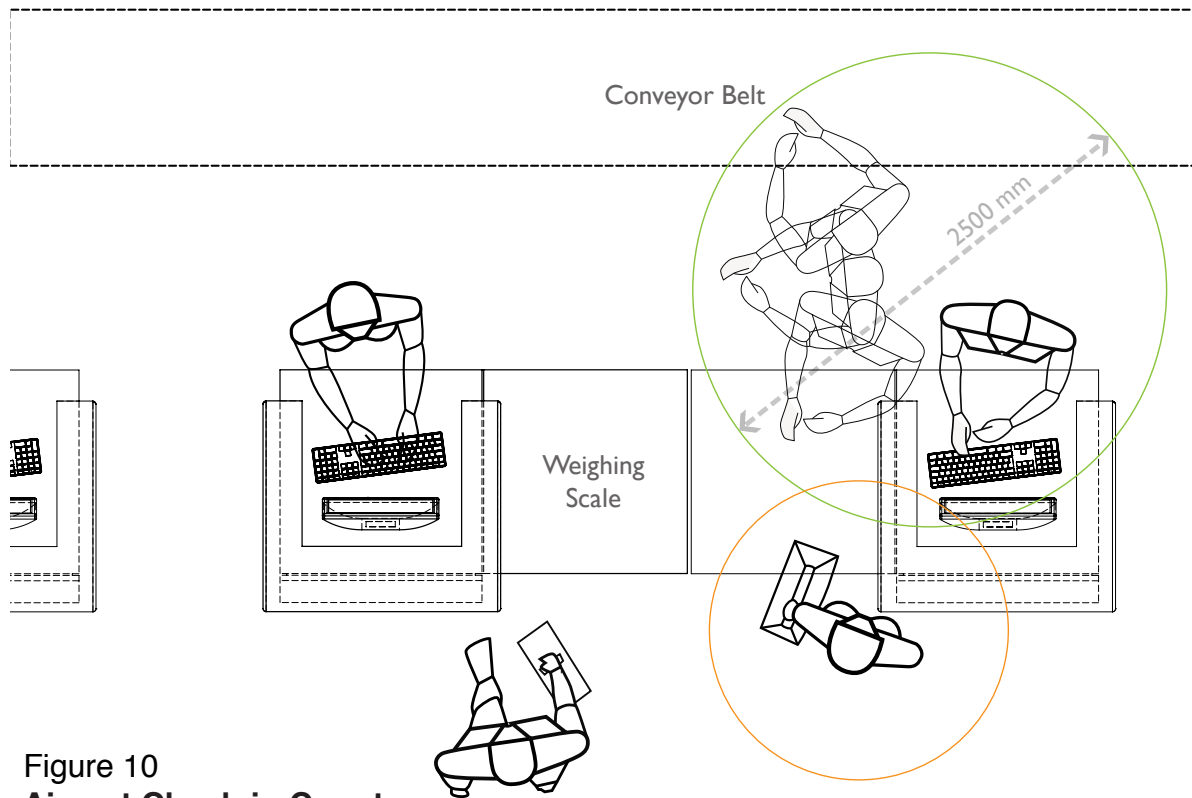


Figure 10
Airport Check-in Counter
 Movement Patterns for Staff and Guests

Office Reception Counter

The office reception counter observed was located in the administrative office of a major research university. The office reception working hours were from 8:00 am till 5:00 pm Monday to Friday with an hour break for lunch. The main activities apart from reception work, were filing paperwork for different departmental activities and miscellaneous housekeeping duties. The administrative office also doubled as the student coordinator's office for the College, and the receptionist's duties included scheduling of appointments with the student coordinator. Observational research

revealed that the job was primarily sedentary but there were a range of activities around the workspace which required a kind of '*hovering*' stance over the counter while multitasking. Most frequent motions were between the screen, telephone and the printer. There was frequent need to retrieve files from the nearby file cabinet to check records. There were occasional one-to one interactions with other staff or students seated across the counter.

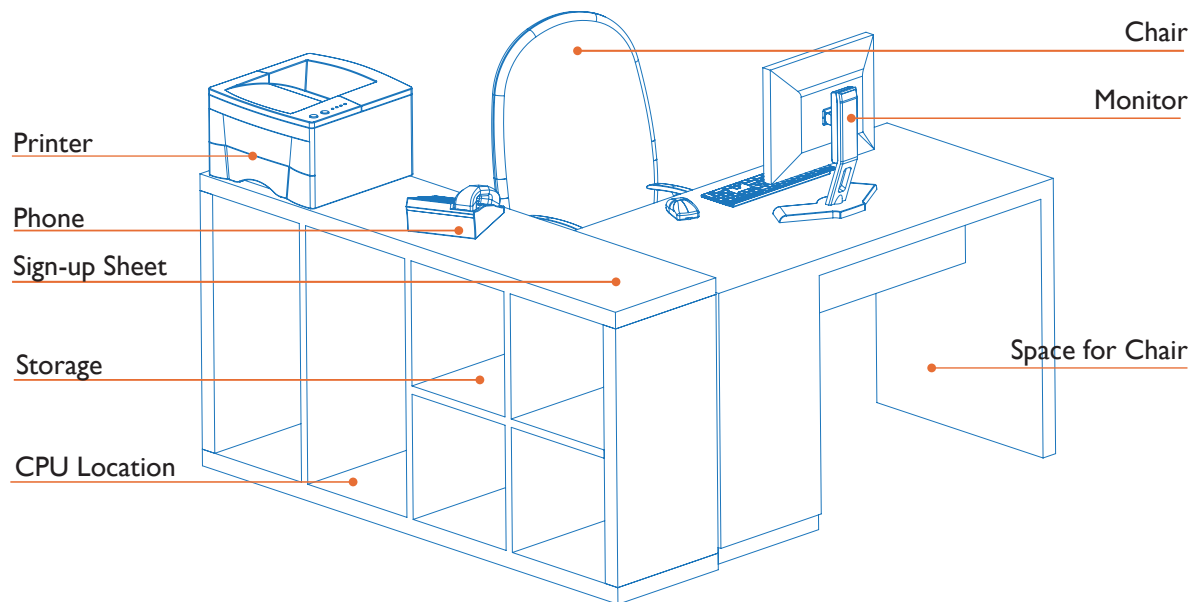


Figure 11
Office Reception Counter
Environmental Audit and Devices

One common pattern observed was the growth of digital devices over the counter which reduced '*useable*' counter space for office work. This mismatch between digital technologies and environmental design is an opportunity to integrate some of the ubiquitous technologies into the physical fabric of the workspace, leading to technology integrated designs that facilitate ease of use. The environmental analysis provided hints about how the work-area could be zoned into public, semipublic and private areas according to the nature of work. The image below shows the staff and student movement patterns around the counter space.

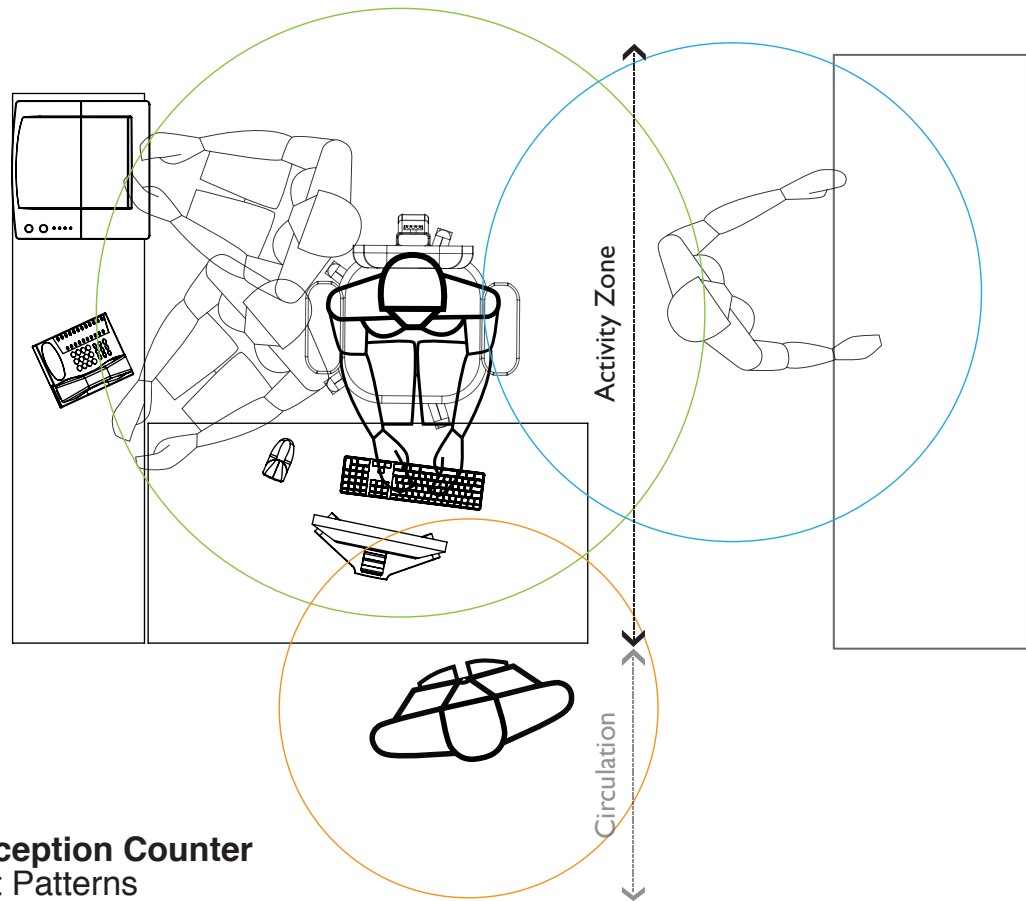


Figure 12
Office Reception Counter
 Movement Patterns

Registration Counter

Registration counters are typically temporary kiosks set-up for events such as conferences and trade shows where participants can check-in and collect their registration kits. The work hours are typically between 1-3 hours in the morning. Users were observed at registration counters in a conference facility in midtown Atlanta that had four separate events for which registrations were taking place. There were four counters staffed by employees who had to check identity of participants, print their tags, complete registration paperwork and give them registration kits. Due to the dynamic nature of the work, there were no defined positions for employees at the counter. There were no wheelchair accessible counters at this location and no participants in wheelchair were present.

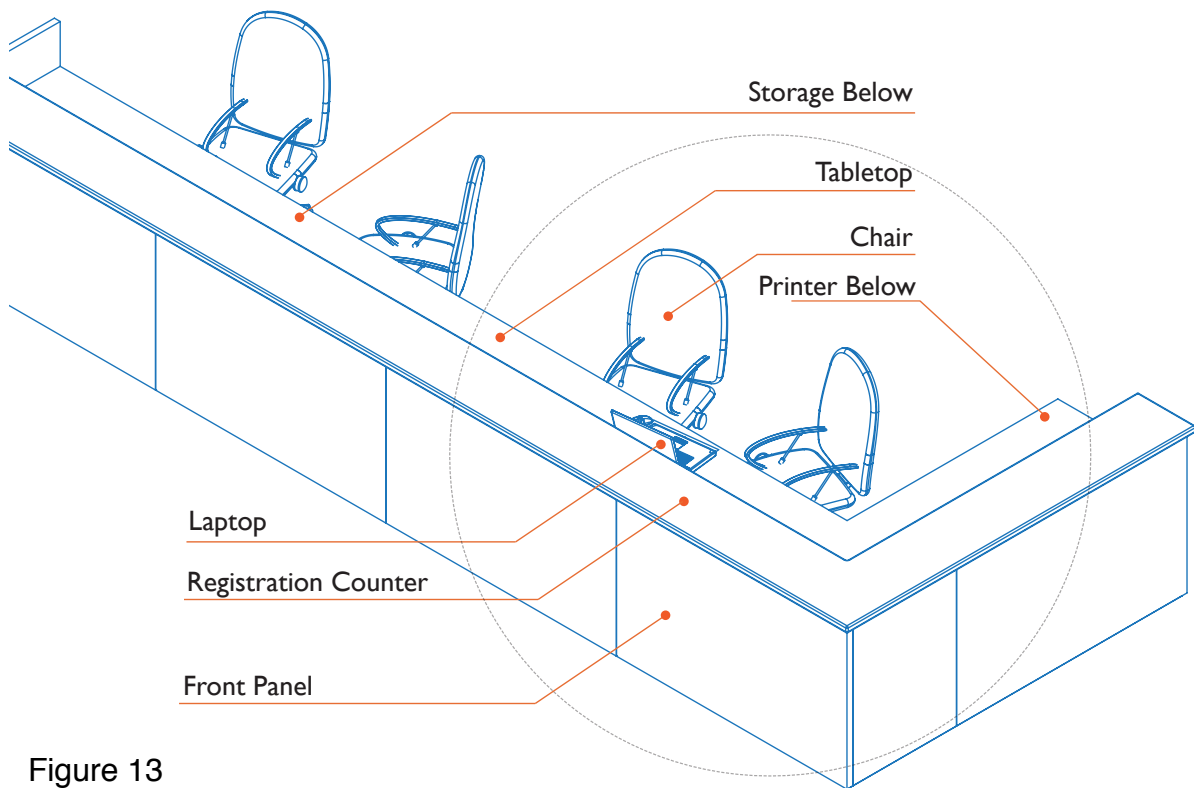


Figure 13
Registration Counter
 Environmental Audit and Devices

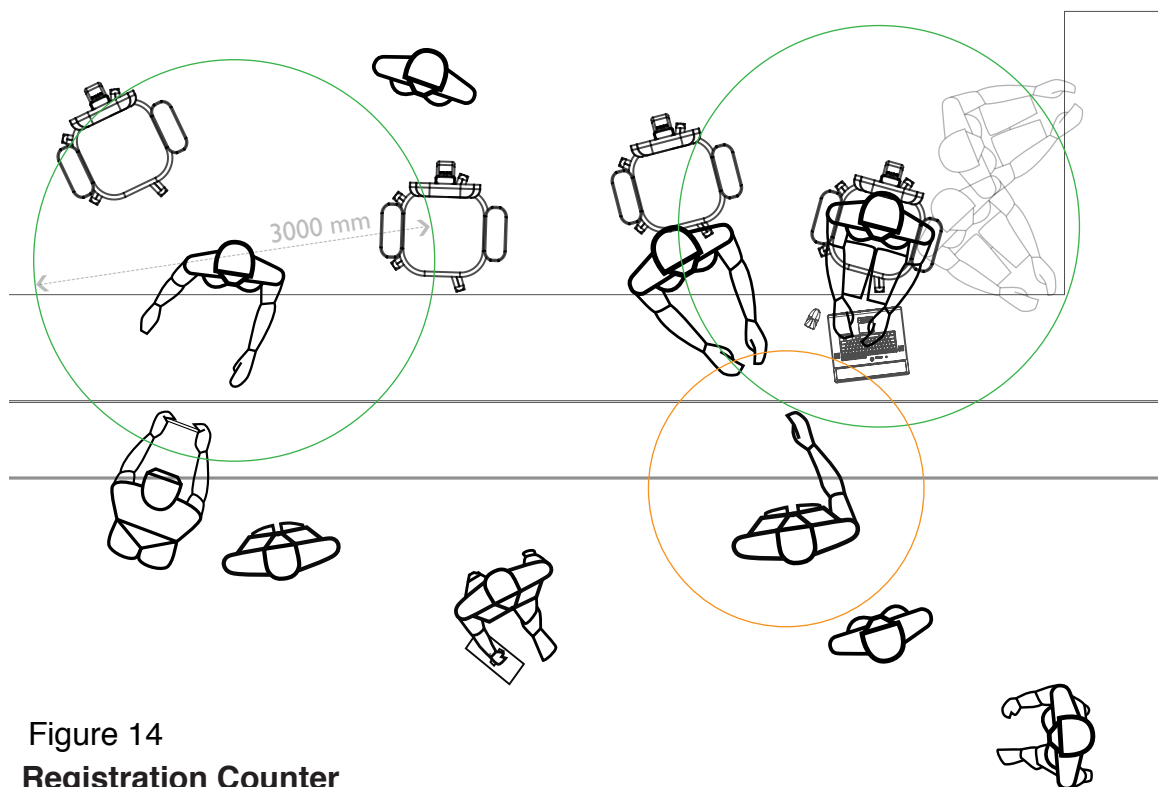


Figure 14
Registration Counter
 Movement Patterns of Staff and Visitors

Findings from the Environmental Study

The key findings from the environmental study were:

1. **Environmental Audit** - The study enabled classification of the spatial design of behind-the counter workspaces. The elements of the design were classified as planes, surfaces, storage, seating and structure. Planes are the horizontal work surfaces, mainly on the staff side but in a few cases a smaller surface for the customer side was also observed. The dimensions of surfaces varied across professions and so did the shapes. *The new designs need to offer a range of horizontal surfaces.* Height adjustment did not feature in any of the designs and wheelchair access was only provided in the customer side. Vertical surfaces were mostly at the customer-staff interface and were fairly consistent in terms of their dimensions and shapes, but varied in materials and finishes. Storage space and zones varied depending on the nature of work. *As a solution, modular storage elements need to feature in the new designs.* The libraries featured the greatest storage volumes while office receptions also featured multiple storage areas. Also, positioning of storage areas was found to be critical in professions dealing with frequent storage and retrieval. Seating was absent in hotel environments and except for office receptions, all other professions featured a mix of work while seated or standing. *This signifies the need for temporary seating solutions with a possibility of integrating them into the workspace design.* The underlying structure for all the five workspaces was fairly conventional with plywood, high density fibreboard or sheet metal components connected by metal fasteners.

2. **Movement Patterns** - The movement patterns of people on the staff side highlighted success and failures of the existing designs. These patterns try to capture the dynamic nature of work and provide a visual representation of the environmental fit between user and space. A consistent pattern that emerged from studying all five workspaces was the realization that the range of user activities is spread over a broad area of which the counter is one of the major spaces. *For a comprehensive design, the solution has to consider all the touch points in the user environment matrix.*

- 3. Insights from Users** - User insights from non structured interviews enriched the research and highlighted issues about the design that were not adequately captured by naturalistic observation. Users shared anecdotes about work and were vocal about their preferences and dislikes of their workspaces. Most users also had specific workarounds for the lack of 'fit' between their needs and the environmental design. These user insights ranged from how individuals zoned out their workspaces into specific work zones for different tasks to how they reconfigured their space to suit specific needs. Users made suggestions about what features were lacking in current designs that they would like to see in future versions.
- 4. Environmental Factors** - Certain environmental factors like ambient noise levels, indoor air quality, glare, task lighting, privacy featured prominently in informal conversations with users. While some of these factors are shaped by the building envelope and environmental services and, are beyond the scope of workspace design per se, nevertheless, they broaden the scope of the design and have to be taken into account during the conceptualization process.
- 5. Technology Audit** - The technology audit studied the range of work technologies used in the five work settings and explored commonalities and linkages between them. There was a common pattern of profusion in digital devices over the counter that were meant to reduce human effort and streamline processes, but the mismatch of technology and its integration into the physical workflow resulted in cluttered layouts, unhappy customers and disgruntled employees. The need is for creating a new generation of workspaces that integrate some of the common devices into the macro environment, resulting in more efficient designs that staff and customers can configure to suit their exact requirements.

Chapter 7: Usability Study

The usability study looked at how design of the environment and location of devices affected workflow of the users. While the environmental study looked at the design of the environment, this particular research was about how people used the workspaces, what they liked, what they disliked, what could be improved and how, and what had to be redesigned from scratch. The study looked at pros and cons of contemporary behind-the-counter workspaces from an user-centered perspective. Observational research revealed inferences from which were derived initial design specifications that translated into the final design solution.

Methodology

Five specific work-types, namely - library circulation counter, hotel check-in counters, airport check-in, office reception and registration counters were studied. These observational studies were conducted over a period of two months in spring 2010 in the Atlanta area. User consent was obtained in writing before the studies and confidentiality of the research data was strictly enforced. Each of the workspaces was observed for two separate days of the week, for hour-long sessions at two specific times of day, a) during the peak work period as reported by the users and b) during lean work period between peaks. This sequence of observations enabled a fairly accurate representation of the range of tasks and the peaks and troughs of customer service activity over a typical work week. Usability study primarily involved taking notes of the disabling or enabling characteristics of the workspace. One hour long video recordings were made of the workspaces with the camera placed in a strategic location to get a view of the activity from both sides of the counter. Because of requests from counter staff, the videos did not capture images of customers across the counter. There were informal interviews with counter staff after the video recordings were done. Findings from the video recordings were tied in with user responses during the usability studies

Subjects

The number of subjects studied varied according to the nature of activity and scale of the work facility. In the library counter four individuals were operating the counters during the peak hours and two during non-peak hours. Hotel check-in counter had a provision for four staff members behind the counter, but only two counters were occupied. For airport check-in counter the observational research was narrowed down to two check-in counters from one of the leading airlines occupied by one check-in staff each. Observational research at two separate receptions within the administrative offices of a major research university involved one staff member each. The registration counters were within a conference facility in a university setting and were operated by four staff members at peak hours and by two members at non-peak hours.

Observation

Each of the video recordings were reviewed and particular frames were highlighted to show the problems in usability. Analyses of the video were tied in with data from the informal interviews. The study enabled a usability audit of each work environment that was then coded for positive and negative features associated with each workspace. Inferences were generated from observations and possible design specifications for the new designs were documented. The study laid the foundation for building a set of design specifications based on observational research combined with contextual interviews. The following pages highlight significant findings from the usability study in the five specific workspaces that were studied as part of this project. The findings from this research are provided at the end of the section.

Library Check-in Counter



Library Counter
Arrangement of Devices
Figure 15

Observations

- 1 Demagnetizer away from workflow
- 2 No indication of book drop-off zone
- 3 Telephone rarely used
- 4 Monitor interferes with interaction
- 5 Common cable inlet
- 6 Barcode scanner away from workflow

Inference

- workflow not reflected in arrangement of devices
- monitor needs to be relocated to enable better interaction with customer - presently most devices arranged around the monitor without regard to sequence of activities
- separate locations of bar code scanner and demagnetizer hinders workflow
- no defined book drop-off zone for check-out/return

Design Specs

- design a drop-off zone for books and other items
- explore possibilities of locating monitor below surface or any other area, to facilitate face to face communication on both sides of counter
- integrate barcode scanner and demagnetizer into workflow
- design possible locations for devices based on right/left handed operation
- provide for cable management



Figure 16
Library Counter
Staff side view

Observations

- 1 Chair rarely used (< 2 mins at a stretch)
- 2 No wheelchair accessible counter
- 3 Scanner location hinders workflow
- 4 Low bookshelf increases bending down
- 5 Demagnetizer far from scanner
- 6 CPU placed too low for access

Inference

- Monitor placement critical in creating conditions conducive for over-the-counter interactions
- Scanner and demagnetizer at an optimum location to assist in check-in/check-out workflow
- Provide for wheelchair access on both sides of counter
- Integrate seating with counter to allow work while seated as well as while standing
- Curved shape of counter in plan creates illusion of greater space

Design Specs

- Design for wheelchair access on both sides of counter
- Optimize counter height to allow work in both seated as well as standing postures
- Specify monitor placement to enable face to face interaction over-the-counter
- Integrate demagnetizer and scanner to optimize workflow and reduce visual clutter

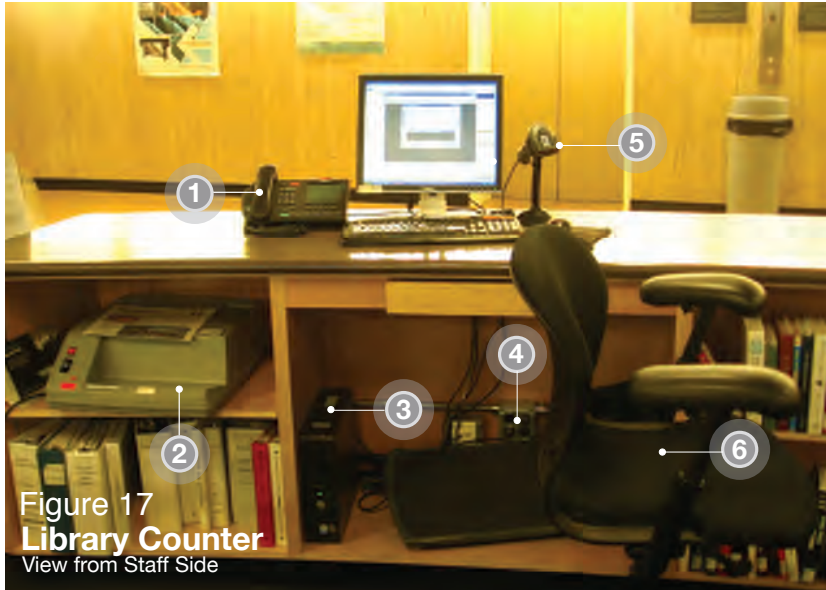


Figure 17
Library Counter
View from Staff Side

Observations

- | | |
|------------------------------|--|
| 1 Telephone rarely used | 4 Power and Network connections |
| 2 Demagnetizer below counter | 5 Barcode scanner in heavy usage |
| 3 CPU just above floor level | 6 Chair rarely used...hinders workflow |

Inference

- CPU needs to be raised for easier access
- Demagnetizer and scanner to be integrated for enabling an efficient workflow
- Provision for multiple power and network outlets
- Easier access to books
- Integrate seating with counter enabling of seated and standing postures at work

Design Specs

- Position devices and storage within reach envelope
- Integrate barcode reader with monitor to aid workflow
- Provide book racks that angle upward for easier access
- Provide built-in seating within counter eliminating separate chairs
- Provide clearspace below counter for wheelchair users

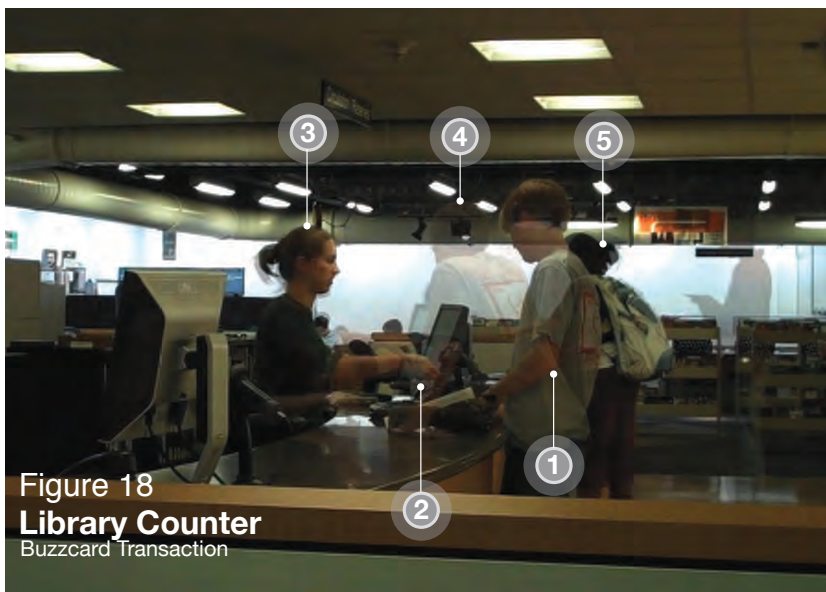


Figure 18
Library Counter
Buzzcard Transaction

Observations

- | | |
|---|--|
| 1 Student provides buzzcard to staff | 4 Staff rotates monitor to share screen with student who leans forward to view screen data |
| 2 Staff scans card to "read" student info | 5 Student at adjoining counter |
| 3 Staff views screen data | |

Inference

- Need to share screen in some transactions
- Card reader and monitor need to be in sequence to assist in smooth workflow
- Need for alternative monitor for students to view their library transaction details
- Need for a flexible system that allows equitable access to people in wheelchairs for library transactions

Design Specs

- Provide information display for both sides of counter
- Integrate barcode reader with monitor to aid workflow
- Enable flexibility in right/left handed transaction on both sides of counter
- Design a flexible workspace that enables equitable access for people in wheelchairs

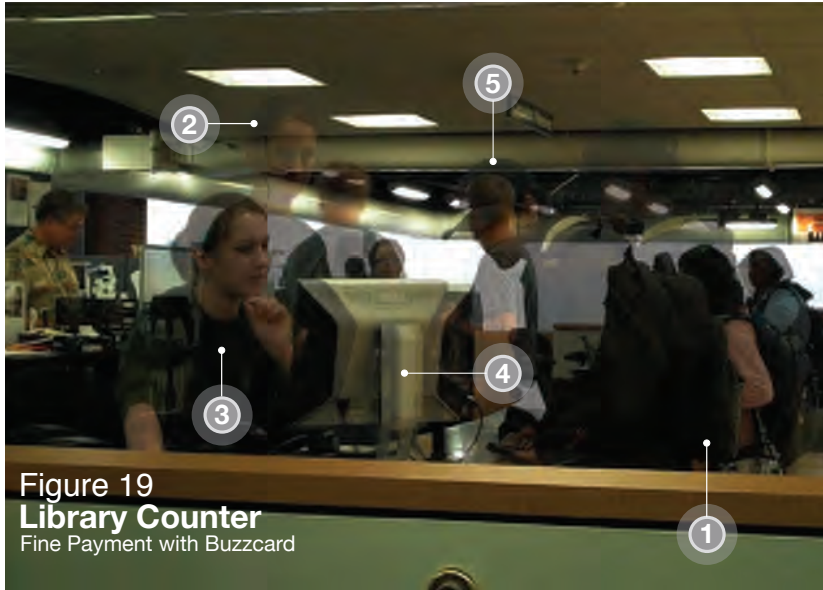


Figure 19
Library Counter
Fine Payment with Buzzcard

Observations

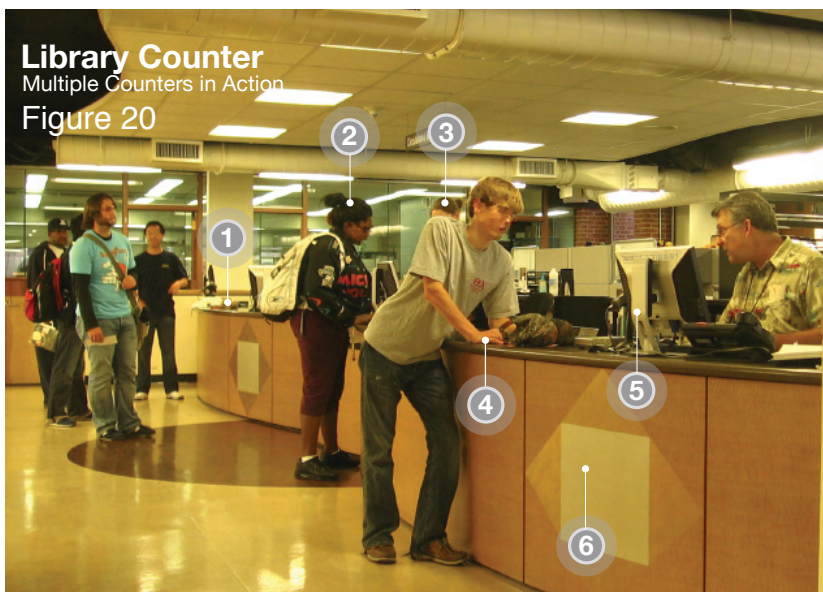
- 1 Student provides buzzcard
- 2 Staff takes card and scans in reader
- 3 Staff sits down while viewing screen
- 4 Staff rotates monitor for student to see transaction details and library fine
- 5 Student leans forward to view screen

Inference

- Need to share screen in some transactions
- Card reader and monitor need to be in sequence to assist in smooth workflow
- Need for alternative monitor for students to view their library transaction details
- Need for a flexible system that allows behind the counter work in seated and standing positions

Design Specs

- Provide information display for both sides of counter
- Integrate barcode reader with monitor to aid workflow
- Provide credit card reader and receipt printer within workspace
- Provide built-in seating within counter to allow work in both seated or standing postures



Library Counter
Multiple Counters in Action
Figure 20

Observations

- 1 Student places belongings on counter
- 2 Student returning books
- 3 Staff standing and checking in books
- 4 Student leans on counter while interacting
- 5 Monitor comes in way of interaction
- 6 No provisions for wheelchair access

Inference

- Monitor placement critical in creating conditions conducive for over-the-counter interactions
- Need for separate ledge for users to keep handheld objects, bags etc during interaction
- Provide for wheelchair access
- Provide clearance for toe at junction of floor and counter
- Curved shape of counter in plan creates illusion of greater space

Design Specs

- Design for wheelchair access on both sides of counter
- Design an attachable ledge in front for users to temporarily keep belongings
- Optimize counter height to allow work in both seated as well as standing postures
- Specify monitor placement to enable face to face interaction over-the-counter
- Create modules that can be configured in various geometric formulations as required

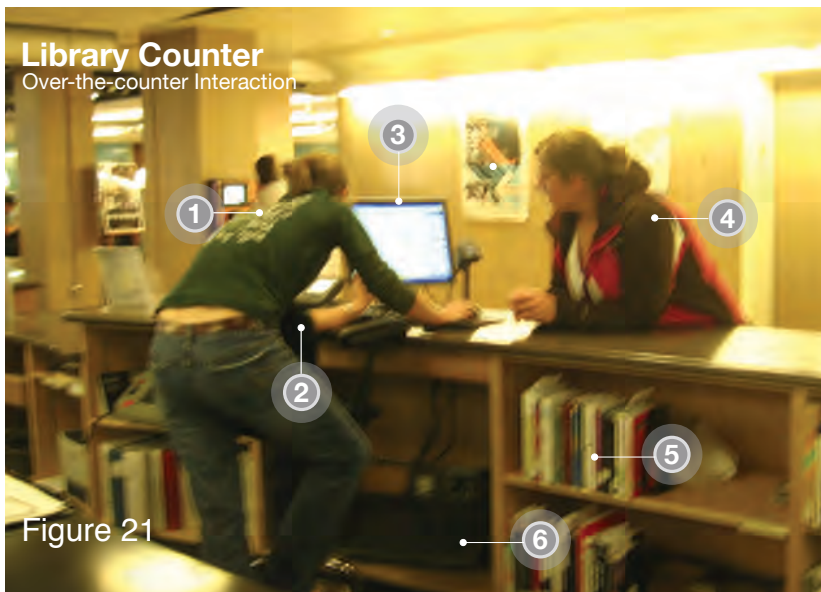


Figure 21

Observations

- | | |
|----------------------------------|--|
| 1 Staff leans over chair | 4 Student leans forward to view screen |
| 2 Chair comes in way of work | 5 Books reserved for pick-up |
| 3 Screen rotated for mutual view | 6 Footrest used when sitting |

Inference

- Chair hinders workflow and creates conditions that lead to awkward body postures
- Need for dedicated monitor for users on other side of counter
- Create easier access to books
- 'Float' devices above work surface to create more use-able counter space
- Eliminate separate chairs, while providing seating options for staff behind the counter

Design Specs

- Dual monitors for staff and users on other side of counter
- Integrate barcode reader with monitor to aid workflow
- Provide book racks that angle upward for easier access
- Provide built-in body supports within counter eliminating separate chairs
- Fix devices on floating arms to clear counterspace and allow easy customization by staff

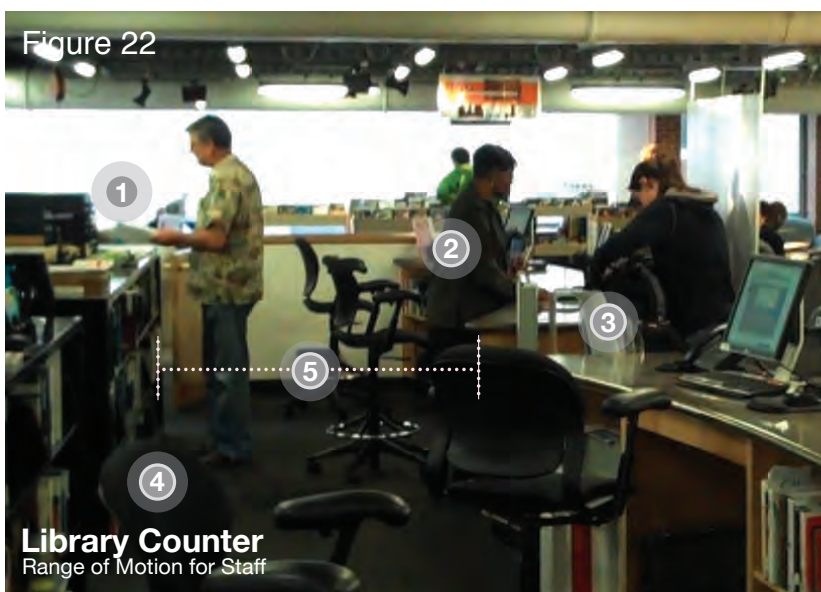


Figure 22

Library Counter Range of Motion for Staff

Observations

- | | |
|-------------------------------------|---|
| 1 Staff #1 at bookshelf | 4 Chairs rarely used...clutter the space |
| 2 Staff #2 attending to student | 5 Minimum 4'0" clearance between counter and bookshelf behind |
| 3 Student resting bag on countertop | |

Inference

- No fixed position for staff - all counters shared by staff
- Work involves frequent movement between counters and storage area behind
- Need for spaces that enable collaborative work on both sides of the counter
- Design surfaces and devices that reduce instances of staff bending down or leaning over

Design Specs

- Design counter with body supports instead of chairs.
- Angle storage shelves upward for easy access
- Provide ledge for resting bags on customer/student side of the counter
- Design storage counters with inclined racks for easier handling of books



Figure 23
Library Counter
Staff Collaboration

Observations

- | | |
|---------------------------------------|---|
| 1 Staff #1 leaning over counter | 4 Staff #2 goes back to his counter |
| 2 Staff #2 watching same screen | 5 Student rests palms on counter while waiting for checking out items |
| 3 Monitor shared during collaboration | |

Inference

- No fixed position for staff - all counters shared by staff
- Work involves frequent movement between counters and storage area behind
- Need for spaces that enable collaborative work on both sides of the counter
- Design surfaces and devices that reduce instances of staff bending down or leaning over

Design Specs

- Design modular systems that can be rapidly customized for needs of each staff member
- Design counter for primary usage by staff while standing, and incorporate built-in seats that can be folded inside when not in use
- Create different layouts that foster collaboration on both sides of the counter

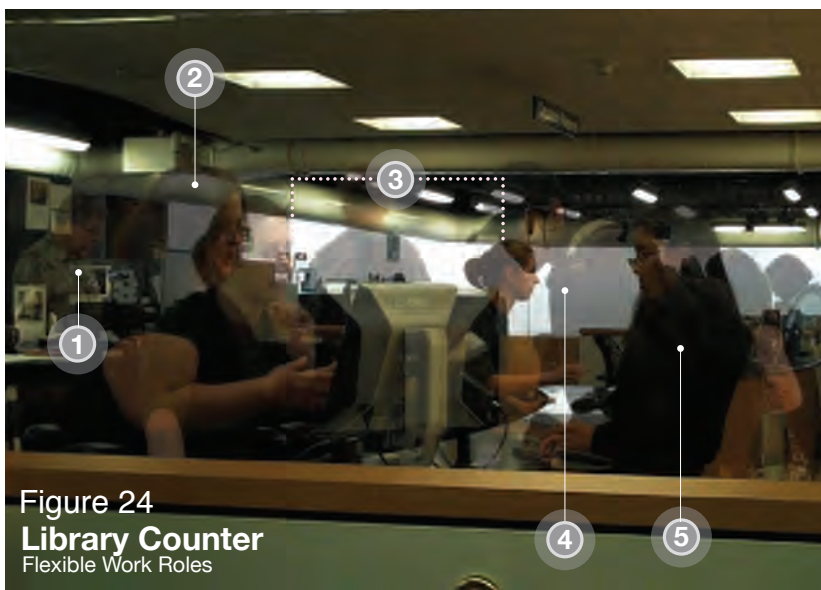


Figure 24
Library Counter
Flexible Work Roles

Observations

- | | |
|-------------------------------------|--|
| 1 Staff #1 retrieving CD from shelf | 4 Student #1 leaning forward to view late return fine details on monitor |
| 2 Staff #2 Checking out book | 5 Student #2 about to check out books |
| 3 Staff #3 at work in two counters | |

Inference

- No fixed position for staff - all counters shared by staff
- Work involves frequent movement between counters and storage area behind
- Need for spaces that enable collaborative work on both sides of the counter
- Monitor comes in way of over the counter interaction

Design Specs

- Change present location of monitor to facilitate better over-the-counter interaction
- Provide a dedicated monitor for customers/students on the other side of counter
- Design a flexible module that allows quick customisation of workspaces and devices to support the fluid workflow

Hotel Reception Counters



Figure 25
Hotel Reception in Action
Guests Checking-in

Observations

- | | |
|---|--|
| 1 Staff interacting with guest at counter | 4 Guest keeps white poster on ledge in front |
| 2 Guest produces reservation document | 5 Guest waits for turn at counter |
| 3 Staff talking on the phone at counter | 6 Other guests wait for their turn |

Inference

- Need for ledge for guests to place hand luggage during check-in/check-out
- Monitor placement below eye level facilitates over-the-counter interaction
- Need for a wheelchair accessible counter
- Need for a flexible system that allows behind the counter work in seated and standing positions

Design Specs

- Design a ledge for guests to place their hand luggage during transactions
- Design a variable height counter enabling wheelchair access when required
- Design a flexible module that allows for different geometrical configurations
- Provide built-in seating within counter to allow work in both seated or standing postures



Figure 26
Hotel Reception in Action
Side on view of staff zone

Observations

- | | |
|---|---|
| 1 Credit card receipt printer on countertop | 4 Monitor location facilitates interaction |
| 2 Printer on countertop | 5 Files with individual guest information |
| 3 Guest places elbow on ledge | 6 Staff leans forward and places leg on shelf |

Inference

- Lack of use-able counter space due to profusion of devices on countertop
- Leaning posture of staff suggests the need for counters that enable work while seated or standing
- Optimize storage zones to prevent need for bending
- Reduce counter width to enable better interaction between staff and guest

Design Specs

- Position devices on arms or moveable supports to create use-able counter space
- Design a variable height counter enabling wheelchair access when required
- Design locations for devices like credit card reader, printer etc for easy access
- Provide built-in seating within counter to allow work in both seated or standing postures



Figure 27
Hotel Reception
Reach Envelope for Staff

Observations

- | | |
|--|---|
| 1 Raised counter for guests | 4 Extended reach envelope for staff |
| 2 Keyboard+mouse+monitor | 5 Optimum reach envelope for staff |
| 3 Separate counter for basic groceries | 6 Staff rests left leg on shelf for support |

Inference

- Lack of use-able counter space due to profusion of devices on countertop
- Integrate devices into the workflow to optimize usage and reduce repetitive movements
- Optimize storage zones in optimum reach envelope to reduce bending down
- Provide options for work in both seated and standing postures

Design Specs

- Position devices on arms or moveable supports to create use-able counter space
- Provide possible locations for devices based on their frequency of usage
- Eliminate storage at lower levels and also provide leg-space below counter for wheelchair access
- Provide built-in seating within counters to enable work in seated posture

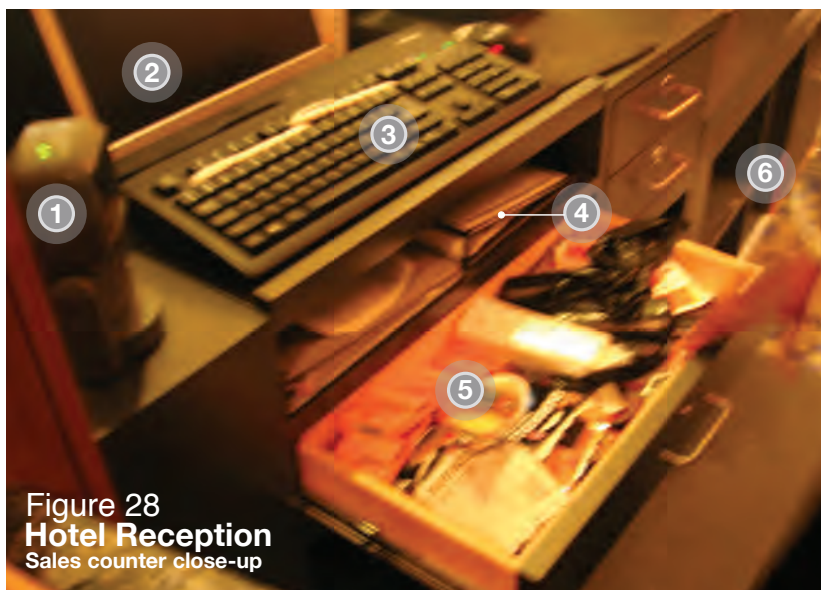


Figure 28
Hotel Reception
Sales counter close-up

Observations

- | | |
|--------------------------------------|--|
| 1 Bar-code scanner on countertop | 4 Storage for files below countertop |
| 2 Monitor positioned below eye level | 5 Lockable storage for items on sale |
| 3 Keyboard and mouse at fixed level | 6 shelves and drawers below countertop |

Inference

- Lack of use-able counter space due to profusion of devices on countertop
- Integrate devices into the workflow to optimize usage and reduce repetitive movements
- Optimize storage zones in optimum reach envelope to reduce bending down
- Allow variable heights for positioning frequently used devices keyboards, mice etc

Design Specs

- Position devices on arms or moveable supports to create use-able counter space
- Provide possible locations for devices based on their frequency of usage
- Eliminate storage at lower levels and also provide leg-space below counter for wheelchair access
- Design a flexible system that allows a range of working heights, allowing users to customize



Figure 29
Hotel Reception
Island Unit from Guest Side

Observations

- | | |
|--|--|
| 1 Ledge for guests to keep handluggage | 4 Counter-top for staff at intermediate height |
| 2 L shaped wrap around top-counter | 5 Pattern over ledge enable customization |
| 3 Monitor with brochure in front | 6 Recess at floor level for toe insert |

Inference

- Split-level counters allow for flexibility in use
- L-shaped counter provides for more useable space in the same footprint
- Island counter unit gives a more personalized feel to the interaction
- Use of geometric patterns over front ledge enriches the visual experience of the counterspace

Design Specs

- Design for multiple planes to provide flexibility in use as well as enable equitable use
- Design a flexible system that allows units to work in group or independent formation
- Provide scope for different stylization options with color, finish and materials
- Provide space at floor level to allow for toe insert
- Optimize location of monitor to facilitate interaction



Figure 30
Hotel Reception in Action
Close-up of Island Unit

Observations

- | | |
|--------------------------------------|--|
| 1 Keyboard+Mouse+Monitor arrangement | 4 Coffee cup placed on ledge by guest |
| 2 Bar-code scanner next to monitor | 5 Basket with office stationery |
| 3 Credit card printer next to mouse | 6 Storage and printer below countertop |

Inference

- Countertop crammed with devices, need for a systems approach to design a layout that provides useable space
- Integrate devices to create a smooth workflow
- Provide a hierarchy for location of devices based on frequency of usage
- Provide for storage and retrieval zones within optimal reach envelope

Design Specs

- Design a support structure to float monitor and other devices, thereby creating useable counter space
- Design storage and retrieval zones within optimum reach envelope, obviating need for overextension of arms and upper body
- Integrate devices within furniture to create a modular, yet integrated system

Airport Check-in Counter



Figure 31
Airport Counter in Action
Baggage Weighing at Counter

Observations

- | | |
|---|--|
| 1 Self Check-in Kiosk in front of counter | 4 Staff processing ticket info on screen |
| 2 Passenger searching for ticket in bag | 5 Passenger placing baggage on scale |
| 3 Passenger bending down to close bag | 6 Weight display and barcode scanner |

Inference

- Provide ledge in front of counter for passengers to place handbag, jacket etc while retrieving ticket
- Provide grab bars on both passenger and staff side for support when loading and unloading weigh scale
- Provide option to integrate display screen with counter
- Provide flexibility in design to allow for wheelchair access on passenger side

Design Specs

- Design L-shaped layout to facilitate baggage handling
- Design grab-able features around the weigh scale for users to grab during loading and unloading baggage
- Design to integrate display and barcode scanner on passenger side of counter
- Design for wheelchair access on passenger side



Figure 32
Airport Check-in Counter
Linear Arrangement of Dual Unit Counters

Observations

- | | |
|--|---|
| 1 Passenger checking-in at counter | 4 Curved ledge for passengers to keep stuff |
| 2 Staff printing boarding pass and tag | 5 Weighing scale 1'0" above floor surface |
| 3 Flight Information display above counter | 6 Weight display screen on side surface |

Inference

- Reduce height of weighing scale for ease of use
- Provide grab bars on both passenger and staff side for support when loading and unloading weigh scale
- Provide option to integrate display screen with counter
- Provide flexibility in design to allow for wheelchair access on passenger side
- Provide optimized counter layout based on workflow

Design Specs

- Design L-shaped layout for counter to facilitate baggage handling and interaction
- Design grasp-able features around the weigh scale for users to grab during loading and unloading baggage
- Design provision to integrate overhead display panels with check-in counter
- Design for wheelchair access on passenger side



Figure 33
Airport Counter in Action
Passenger Check-in at Counter

Observations

- | | |
|---------------------------------------|---|
| 1 Passenger tagging over-size baggage | 4 Carry on items placed on ledge |
| 2 Staff interacting with passengers | 5 Staff collaborating at counter |
| 3 Passenger looking for ticket in bag | 6 1'0" height of weigh scale from floor |

Inference

- Reduce height of weighing scale from floor level to aid baggage work at counter
- Ledge on passenger side needs to be wider to allow handheld items to be placed
- Understand commonalities in self serve and staff manned counters to create a module that works for either option

Design Specs

- Design wide ledge in front of counter for passengers to place handheld items
- Design add-ons like a small ramp or lifting apparatus to ease lifting luggage on to the weighing scale
- Design a module that can be modified from staff serve to self serve and vice versa with minimum modifications

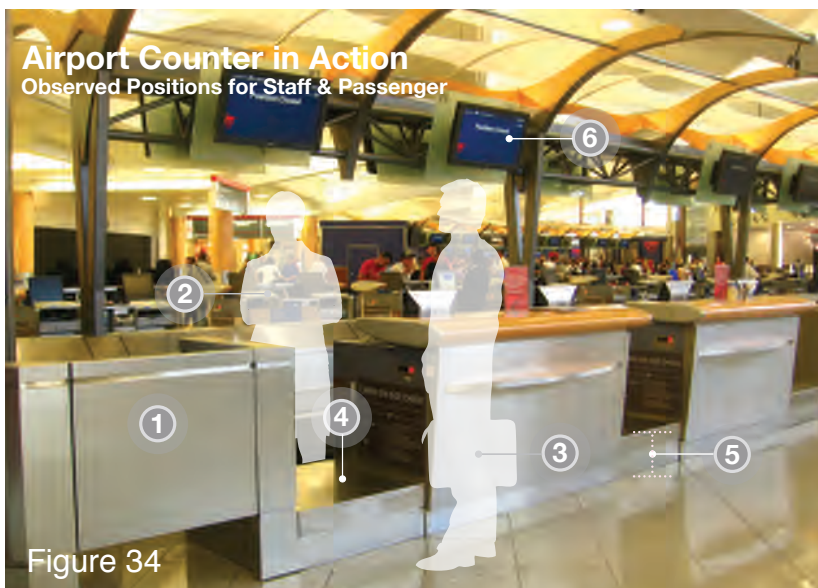


Figure 34

Observations

- | | |
|---|---|
| 1 Stainless steel for finish and durability | 4 Weighing scale with display on counter side |
| 2 Staff standing behind weigh scale | 5 1'0" height of scale from floor level |
| 3 Passenger interacting with staff | 6 Display screens showing flight information |

Inference

- Interaction occurs across the weigh-scale area rather than over the counter
- Reduce height of weighing scale from floor level to aid baggage work at counter
- Ledge on passenger side needs to be wider to allow handheld items to be placed
- Position monitor away from direct line of vision to allow for face-to-face interaction

Design Specs

- Design wide ledge in front of counter for passengers to place handheld items
- Design for wheelchair access on passenger side
- Design counter to facilitate interaction between staff and passengers
- Design grab-bars into the counter to aid in lifting baggage for both staff and passengers
- Install low height weigh scale

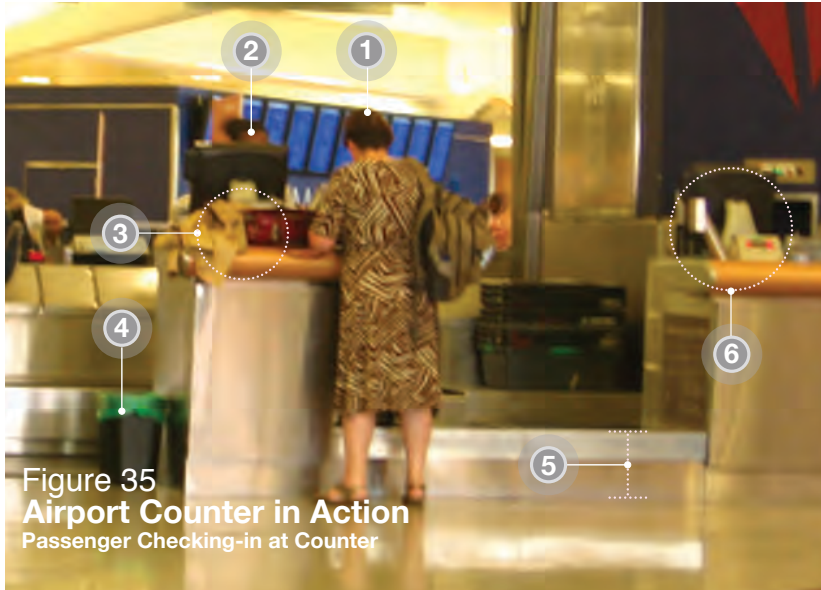


Figure 35
Airport Counter in Action
Passenger Checking-in at Counter

Observations

- | | |
|-------------------------------------|---|
| 1 Passenger checking-in at counter | 4 Trashbag inconveniently located |
| 2 Staff printing boarding pass | 5 1'0" height of weigh scale from floor |
| 3 Jacket and handbag on counter-top | 6 Barcode scanner and weight display |

Inference

- Provide flexibility in counter height to enable equitable use by staff at counter
- Reduce height of weighing scale and conveyor belt to aid baggage work at counter
- Place devices and storage within optimum reach zone
- Integrate trashcan within counter to aid workflow
- Provide for counters that enable work in seated or standing positions

Design Specs

- Design variable height counters with frequently used devices on flexible arm supports
- Design so that storage areas and devices are located in the optimum reach envelope
- Design built-in seating systems that allow work while seated and can be folded into counter when not in use by staff
- Design for wheelchair access on passenger side



Figure 36
Airport Counter in Action
Self Service Counter with Luggage Drop-off

Observations

- | | |
|--|--|
| 1 Passenger navigating screen at counter | 4 Trash can conveniently located but eyesore |
| 2 Passenger waiting for turn at counter | 5 1'0" height of scale from floor level |
| 3 Overhead display with flight information | 6 Display screens showing flight information |

Inference

- Trash can needs to be integrated within the design scheme of the counter
- Reduce height of weighing scale from floor level to aid baggage work at counter
- Ledge on passenger side needs to be wider to allow handheld items to be placed
- Understand commonalities in self serve and staff manned counters to create a module that works for either option

Design Specs

- Design wide ledge in front of counter for passengers to place handheld items
- Design trash can integrated with counter on both staff and passenger side
- Design add-ons like a small ramp or lifting apparatus to ease lifting luggage on to the weighing scale
- Design a module that can be modified from staff serve to self serve and vice versa with minimum modifications



Figure 37
Airport Counter in Action
View from Staff Side

Observations

- | | |
|--|---|
| 1 Conveyor belt behind row of counters | 4 Fixed counter height is a hindrance for users |
| 2 Staff standing at counter | 5 3'6" width between counter and conveyor |
| 3 Passenger weighing baggage on scale | 6 Printer located at lowest shelf |

Inference

- Provide flexibility in counter height to enable equitable use by staff at counter
- Reduce height of weighing scale and conveyor belt to aid baggage work at counter
- Place devices and storage within optimum reach zone
- Provide wheelchair access on both sides of the counter
- Provide for counters that enable work in seated or standing positions

Design Specs

- Design variable height counters with frequently used devices on flexible arm supports
- Design so that storage areas and devices are located in the optimum reach envelope
- Design body supports into the counter to reduce effect of static postures at work
- Design for wheelchair access on both sides



Figure 38

Airport Counter in Action
Wheelchair Access at Check-in

Observations

- | | |
|---|--|
| 1 Raised platform for weighing scale | 4 Staff standing behind check-in counter |
| 2 Ledge for passengers to place stuff | 5 Passenger in wheelchair stretching forward |
| 3 1'0" height of scale from floor level | 6 Display screens showing flight information |

Inference

- Provide counters that allow equitable use for people in wheelchairs
- Reduce height of weighing scale from floor level to aid baggage work at counter
- Ledge on passenger side needs to be wider to allow handheld items to be placed
- Position monitor away from direct line of vision to allow for face-to-face interaction

Design Specs

- Design wide ledge in front of counter for passengers to place handheld items
- Design for wheelchair access on passenger side
- Design a L-shaped counter with monitor away from the direct line of vision of staff
- Design grab-bars into the counter to aid in lifting baggage for both staff and passengers

Office Reception Counter



Figure 39
ID Office Reception
View from entrance to office

Observations

- 1 Printer on countertop takes up prime desktop space
- 2 Lack of a cable management system
- 3 Monitor comes in way of interaction
- 4 Chair for visitor to sit down and interact
- 5 Trash-can not integrated with counter

Inference

- Need to place printer below countertop to create useable space above counter
- Provide options for left and right handed people with respect to positioning of devices and storage
- Provide flexibility in design for personalization of space
- Arrange monitor, keyboard and mouse on supporting arms to allow for flexibility in use and enable face to face interaction over counter

Design Specs

- Design cable management systems for power and network cabling in counter
- Provide trash can within footprint of the counter
- Design for flexibility in arrangement of surfaces, planes and storage zones
- Design brackets and flexible arm supports to mount monitor, keyboard, mouse etc above countertop

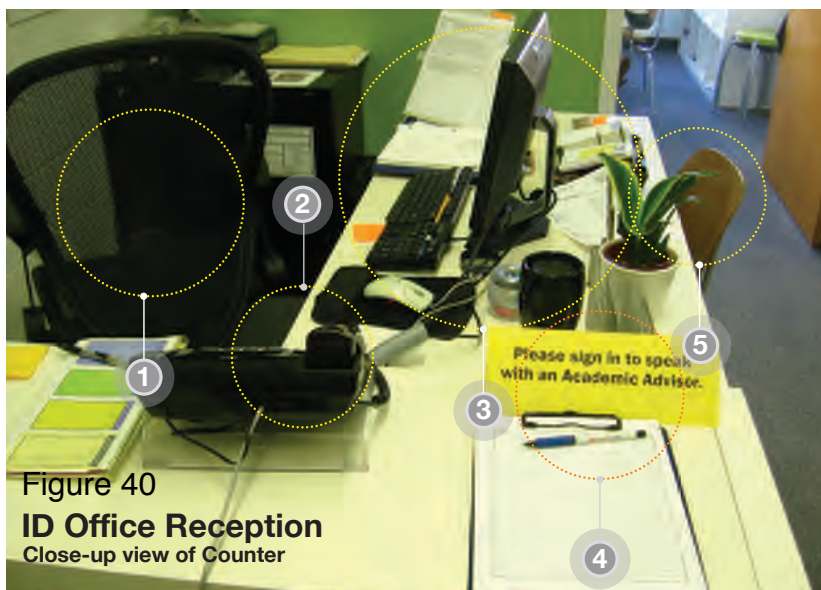


Figure 40
ID Office Reception
Close-up view of Counter

Observations

- 1 Chair with 360 degree swivel enables easy access to all work surfaces
- 2 Phone frequently used at work
- 3 Monitor, Keyboard, Mouse, Reading Stand etc
- 4 Sign-up sheet for students on countertop
- 5 Chair on other side for occasional visitor to sit down and interact with staff

Inference

- Provide worksurfaces and devices along an arc drawn with the chair at the center
- Provide options for left and right handed people with respect to positioning of devices and storage
- Provide flexibility in design for personalization of space
- Arrange monitor, keyboard and mouse on supporting arms to allow for flexibility in use and create useable space on desktop

Design Specs

- Design counter considering the reach envelope of staff while seated at desk
- Design for variability in physical characteristics and preferences of people
- Design for flexibility in arrangement of surfaces, planes and storage zones
- Design brackets and flexible arm supports to mount monitor, keyboard, mouse etc above countertop

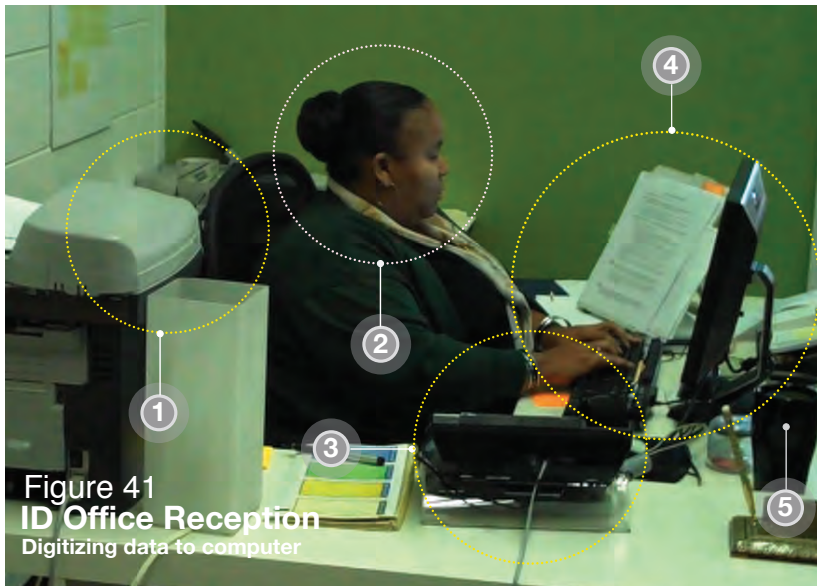


Figure 41
ID Office Reception
Digitizing data to computer

Observations

- | | |
|--|---|
| 1 Printer and table lamp on counter | 4 Monitor and document stand arranged for easy viewing while typing into computer |
| 2 Staff typing on screen while reading from document on stand beside the monitor | 5 Pen stand, pin holder and other assorted items on desktop |
| 3 Phone easily accessible from seat | |

Inference

- Printer needs to be placed below the countertop
- Reading stand and monitor need to be mounted on flexible arm supports
- Phone location on counter should enable both right or left handed usage
- Provide options for users to customize positions of items and devices according to their needs and preferences

Design Specs

- Design multiple options for placement of printer below countertop while being easy to access from the seat
- Design arm supports and brackets to mount monitor, keyboard, mouse and reading stand above counter
- Design a set of parts that enable users to customize their space according to needs and preferences

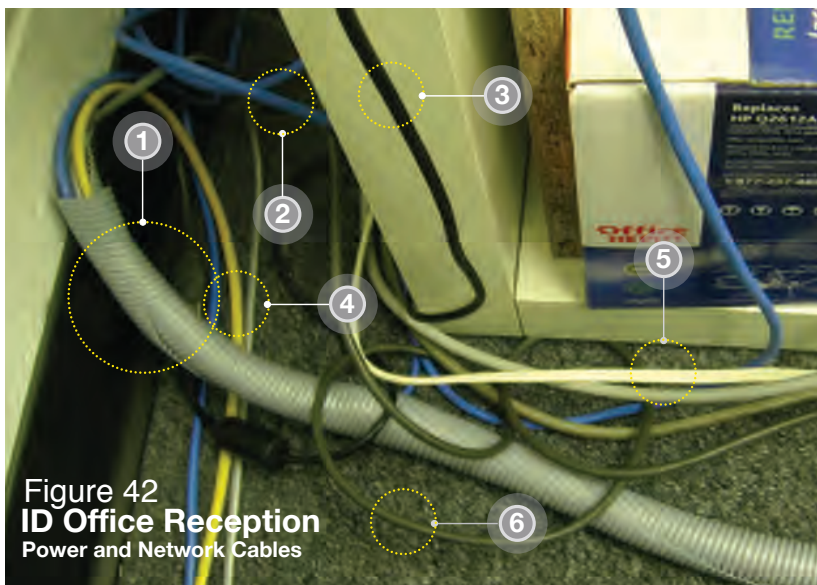


Figure 42
ID Office Reception
Power and Network Cables

Observations

- | | |
|------------------------------------|--------------------------------------|
| 1 PVC conduit for network cables | 4 Yellow = LAN Cable for computer |
| 2 Blue = network cable for printer | 5 White = Power cable for table lamp |
| 3 Black = power cable for printer | 6 Grey = Telephone cable |

Inference

- Types of cables in use:
 - power (black, white)
 - printer (blue)
 - local area network (yellow)
 - telephone (grey)
- Provide power and network outlets through channels at three levels - countertop lvl, below counter lvl and at floor level
- Provide flexible conduit/ wireframe/ extruded channel to integrate cabling with structural elements

Design Specs

- Design modular channels or conduits carrying network and power cables integrated within structural elements
- Design locations for outlets (power and network) to allow for flexibility in placement of devices in the counter
- Design for cabling to connect with floor or wall based cabling systems



Figure 43
ID Office Reception
Range of Actions for Staff

Observations

- | | |
|---|---|
| 1 Staff talks on phone while standing and stretching her legs | 4 Sign-up board in front of counter |
| 2 Phone within easy reach of staff | 5 Monitor comes in way of face-to-face interaction between staff and visitors |
| 3 Staff greets visitor while seated | 6 Staff stands and leans to reach keyboard |

Inference

- Position telephone for easy access by staff while seated or standing at counter
- Position frequently used devices within the optimum reach envelope while seated
- Provide flexibility in both horizontal and vertical axis for positioning devices like monitor, keyboard, mouse, telephone etc
- Position monitor to enable face-to-face communication across the counter

Design Specs

- Relocate printer to below the counter to create useable space on countertop
- Design storage zones within optimum reach envelope for ease of access
- Design arm supports for monitor for flexibility in use
- Design storage zones within optimum reach envelope of staff when seated at counter
- Design variable counter height to enable work while seated or standing

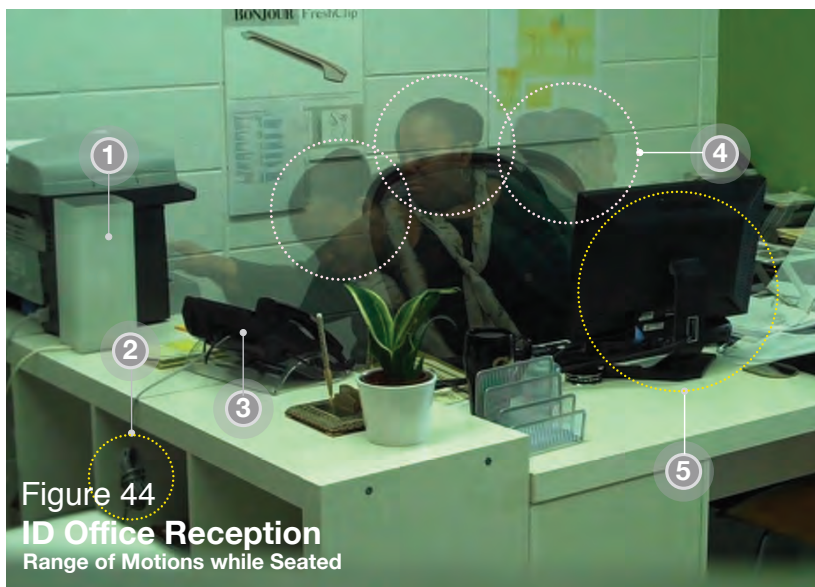


Figure 44
ID Office Reception
Range of Motions while Seated

Observations

- | | |
|--|--|
| 1 Printer on countertop reduces useable space on desk | 4 Staff rotates around a 180 degree arc to perform a range of activities |
| 2 Need for cable management for all powered devices in counter | 5 Location of monitor comes in way of face-to-face interaction with people on the other side of reception desk |
| 3 Phone needs to be placed within easy reach | |

Inference

- Provide printer below the countertop to provide for useable counter space
- Position frequently used devices within the optimum reach envelope while seated
- Provide flexibility in both horizontal and vertical axis for positioning devices like monitor, keyboard, mouse, telephone etc
- Provide cable management for power and networking cables

Design Specs

- Design printer location below countertop to create useable counterspace
- Design power outlets and network ports integrated within counter with built-in cable management systems
- Design arm supports for monitor for flexibility in use
- Design storage zones within optimum reach envelope of staff when seated at counter



ID Office Reception
Need for Cable Management
Figure 45

Observations

- 1 Printer with power cable dangling below
- 2 Coffee cup placed on middle shelf
- 3 Phone placed for easy access
- 4 Phone cable hanging from the side
- 5 Potted plant placed on countertop. Adds to the ambience of the environment

Inference

- Provide power outlets along the edge of countertop
- Provide options in design to allow for personalization of workspaces
- Provide a modular system with integrated cable management eliminating the visual clutter and functional problems associated with cables lying around
- Provide visual barriers to distinguish private and public zones in workspaces

Design Specs

- Design power outlets and network ports along the countertop for easy access
- Design cable management systems to conceal cabling
- Design for flexibility in arrangement of surfaces, planes and storage zones
- Design visual screens that can be easily attached to the structural framework to distinguish public zones from semi-private spaces



ID Office Reception
Staff working at counter
Figure 46

Observations

- 1 Printer occupies prime counterspace
- 2 CPU located below counter
- 3 Phone placed for easy access
- 4 Staff typing on computer while seated
- 5 Monitor comes in way of face-to-face interaction between staff and visitors
- 6 Chair for visitors to sit while interacting

Inference

- Position telephone for easy access by staff while seated or standing at counter
- Provide useable space on desktop by re-positioning devices below counter
- Provide flexibility in both horizontal and vertical axis for positioning devices like monitor, keyboard, mouse, telephone etc
- Position monitor to enable face-to-face communication across the counter

Design Specs

- Relocate printer to below the counter to create useable space on desktop
- Design storage zones within optimum reach envelope for ease of access
- Design arm supports for monitor for flexibility in use
- Design mounting brackets or channels for attachment of devices and for fixing privacy screens, display boards, pin-up boards etc

Conference Registration Counter

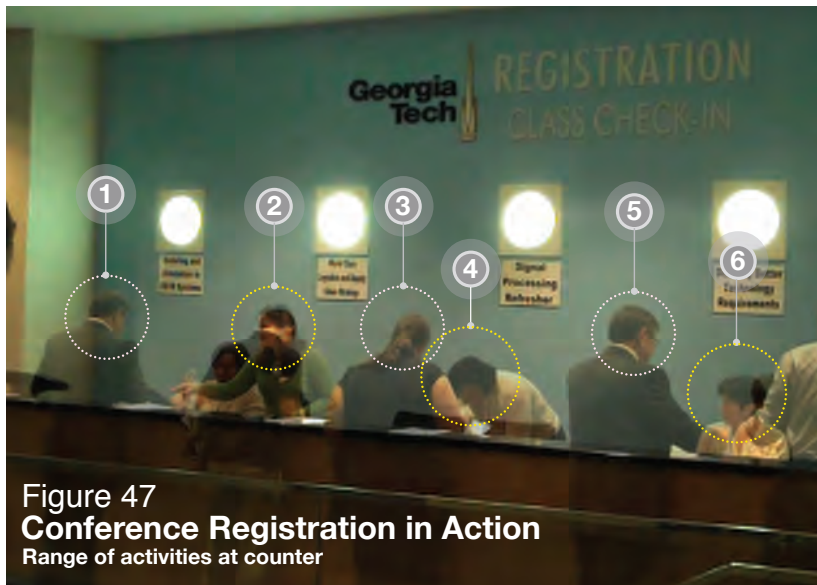


Figure 47
Conference Registration in Action
Range of activities at counter

Observations

- | | |
|--|--|
| 1 Participant is instructed by staff on how to fill in the registration form | 4 Staff bends down while standing to show participant how to fill up registration form |
| 2 Staff points out specific instructions in the form to participant | 5 Participant interacting with staff |
| 3 Participant leans forward on counter | 6 Staff interacting across counter while seated |

Inference

- Nature of work for staff involves frequent bending down. Raising countertop level can address this
- Need for split level counter to provide flexibility in use
- Need to integrate display screens within counter to create independent units which can function in different environments
- Need to allow for behind-the-counter work while being seated or standing

Design Specs

- Design a split level counter enabling flexibility in use by people of varying abilities
- Design a flexible module that allows for addition of vertical members to provide overhead display screens
- Design built-in seating within counters to allow for work while standing or seated
- Design for people on wheelchairs to be able to use the counters



Figure 48
Conference Registration in Action
Interactions across the counter

Observations

- | | |
|---|--|
| 1 Participant moves along counter in absence of well defined counters | 4 Information display indicates counter corresponding to specific workshop |
| 2 Staff manning two counters at the same time in absence of other staff | 5 No visual separation for counters |
| 3 Single level counter reduces flexibility | |

Inference

- Need to raise counterheight on staff side to eliminate need for bending down
- Nature of work involves use of multiple counters by same staff. Provide for quick and easy customization of positions for devices
- Need to allow for behind-the-counter work while being seated or standing
- Provide split-level counter to enable flexibility in use

Design Specs

- Design a split level counter enabling flexibility in use by people of varying abilities
- Design a flexible module that allows for addition of vertical members to provide overhead display screens
- Optimize counter height on staff side to allow for work while seated or standing
- Design mounting brackets and arms for 'floating' devices over counterspace to provide flexibility in use

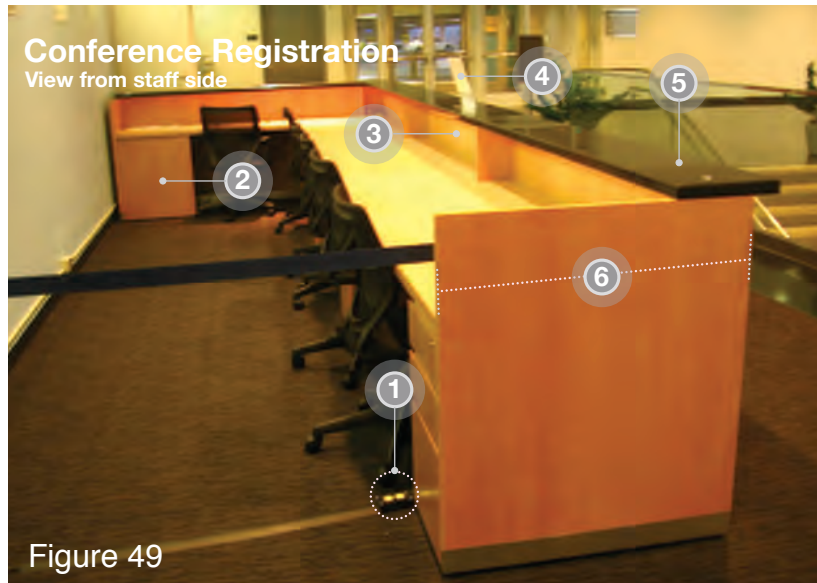


Figure 49

Observations

- | | |
|---------------------------------------|--|
| 1 Power outlet on floor | 4 Brochure on countertop instructs participants about registration process |
| 2 Lockable storage below counter | 5 Single level countertop |
| 3 Small storage area below countertop | 6 3'0" wide counter |

Inference

- Need to optimize counter width to facilitate over-the-counter interactions
- Provide split-level counter to enable equitable use
- Need to provide power and networking ports integrated within counter
- Integrate overhead display panel with counter design
- Provide lockable storage zones within optimum reach envelope of staff

Design Specs

- Design a split level counter enabling equitable use by people of varying abilities
- Design a flexible module that allows for addition of vertical members to provide overhead display screens
- Optimize counter width and height on staff side to allow for work, seated or standing
- Design power outlets and networking ports within the counters, and provide for cable management



Figure 50

Observations

- | | |
|--|--|
| 1 Printer below counter on retractable supports...lockable when not in use | 4 Laptop stored in lockable storage below counter after work hours |
| 2 Small desktop printer for name tags | 5 Counterspace with list of participants |
| 3 Lack of cable management options | |

Inference

- Optimize counter width to facilitate interactions over the counter during work
- Provide for power outlets and networking ports along the counter and incorporate cable management
- Optimize counter height to eliminate bending down
- Provide lockable storage zones within optimum reach envelope of staff

Design Specs

- Design storage zones for various devices within the optimum reach envelope
- Optimize counter width and height for ease of work in standing or seated postures
- Design power outlets and network ports in the counter and cable management
- Optimize usage of vertical space between top ledge and desktop area

Findings from the Usability Study

The key findings from the usability study are:

1. Identifying Usability Issues:

The study was successful in identifying usability problems in all the five workspaces. Naturalistic observation techniques in combination with detailed analysis of the video recordings of work situations enabled both, a visceral feel of usability conflicts in real time as well as an opportunity to share the recordings with my research guide to deliberate causes and inferences as a group. The method of co-evaluating research information reduced the inherent biases. There were common usability trade-offs evident in all the five workspaces. Counter surface height was static in all cases and layouts were not tailored to specific needs of the workflow. For example, in airports the transaction and communication occurred over the weigh scale zone, as the counter shape and the monitor placement interfered with across-the-counter interaction. Similarly, there was a mismatch between the dynamic nature of work in libraries, airports and registration counters which contrasted with rigid, static environmental design of the counters. Location of devices and storage were not optimized for the workflow. Overall, there emerged a common problem space that signified need for a unified, user centered approach towards a solution.

2. Translating Observations into Inferences:

Each of the observations was individually studied and translated into inferences. This method of individually identifying usability conflicts, annotating observations and developing inferences enabled breaking down the work flow into specific instances that could be individually studied and then integrated to build a comprehensive analysis. Observations across the workspaces identified conflicts between the user and environment as well as between user and the technology, which translated into inferences that coalesced into broad design specifications. Similar inferences and specification across the various workspaces tied into the hypothesis of broad commonalities existing among different workspaces. These commonalities foster the development of specifications enabling creation of a

modular design incorporating common features. The specific features not common to the workspace can then be added to this general design.

3. Translating User Responses into Inferences:

User response from employees enriched research findings and provided specific insights about behind-the-counter work from the user's perspective. For instance, hotel receptionists complained of pain in the lower limbs due to work at the counter for long hours in the standing posture. Airport employees talked about injuries at work due to the stress of lifting luggage from the weigh scale to the conveyor belt. Office reception workers mentioned frequently taking a break from their sedentary posture and taking a small stroll in the workspace. The user response was useful in creating an appreciation of the user's real needs and enabled the exploration of empathetic solutions in this regard.

4. Synthesizing Inferences into Design Specifications:

Inferences gathered from observations were synthesized into preliminary design specifications. The synthesis process was the crucial step that transformed ideas into actionable design outcomes. Observations, inferences, user comments were combined to build the specifications. For example, in case of the hotel, airport and library counter, seating was either absent or hardly used due to the dynamics of the work. However, users complained about standing for the duration of the workday. Observational research revealed workarounds to relieve pressure on the legs by partially resting hands on the counter and frequently shifting body weight from one leg to another. In such a context, developing a body support that allowed occasional resting during breaks at work, would reduce the load on the legs and not get in the way of work. In this case, the idea to reduce stress on the lower limbs was the inference and the body support was the preliminary specification.

Chapter 8: Precedent Analysis

Precedent analysis looked at examples of contemporary workstation design understand the modular approach to designing office systems. Product research revealed that most behind-the-counter workspaces were customized designs using combinations of hardware from office furniture systems. This prompted the study of office workstation designs with specific focus on behind-the-counter applications. Some manufacturers had designs for reception counters that were analyzed in detail to reveal insights and investigate shortcomings. The insights and design specs were incorporated into the final design of behind-the-counter workspace. The office system manufacturers studied were:

1. **Vitra Inc**
2. **Herman Miller Inc**
3. **Steelcase**
4. **Knoll Inc**
5. **KI**
6. **Humanscale**

The office systems from these manufacturers were studied in detail using brochures, product guides, promotional literature in print and web. Significant design elements and applications were highlighted and insights from this study were combined with the observational research to create the framework of design. The following pages highlight aspects of design in specific workstation designs that have relevance to our scope of research. The analysis was done in the familiar format first explored in the usability study, featuring a photograph with adjoining column for insights gained and design specifications that could be incorporated in the new design. The visual nature of the research lent itself to such an analysis.

Vitra Terminal Modular Workstation Range



Figure 51

Insights

- Variable height table surface allows work in seated or standing postures
- Power and network cabling integrated within the work surface of the table
- Flexible privacy screens can be installed easily to visually separate workspaces
- Lack of storage spaces in the workstation design will cause problems in daily use

Design Specs

- Use the variable height mechanism to enable work while standing or seated
- Integrate power and network cabling into the design
- Design connections for the attachment of a devices and storage elements into the worksurface
- Design flexible storage options within the design of the modular workspace.

Figure 52

Vitra Ad Hoc Modular Workstation Design



Insights

- CPU on frame with castors for flexibility in use at work
- Power and network cabling raceway integrated with the surface top
- Storage areas above and below the counter surface
- Visual barrier doubles as a light diffuser for workspace
- Flexible screen on castors for occasional privacy needs

Design Specs

- Allow flexibility in hardware system to allow different configurations to be built
- Put cable raceways at table top level for ease of use
- Allow different configurations to mount storage zones both below and above counter
- Allow flexibility to modify workspace into private, semi private and public zones
- Design components with multiple use to reduce total component count



Figure 53
HM Resolve
Modular Workstation Design

Insights

- Structural Frame extends to create superstructure
- Storage and counter top connected to main structure using brackets
- Light diffuser/canopy defines the space and gives distinct visual character
- Various accessories add-on to main structure giving user options for customization
- Power and network conduits integrated into frame

Design Specs

- Integrate power and network cabling into structural frame
- Allow structural frame to support light and signage
- Allow a range of add-on customization options for users to self-organize space
- Design a kit-of-parts to allow various permutations and combinations to provide for a wide range of user needs
- Design accessories for a modular configuration



Steelcase Sync
Modular Workstation Design
Figure 54

Insights

- Pneumatically adjustable height mechanism allows for seated or standing work
- Flexible arm supports for monitor allow users to customise position
- Power and network raceway along linear axis of counter
- Vertical surface features grooves for mounting items
- Footrest rail integrated into the structural element of the counter design in the front

Design Specs

- Allow flexibility workheight to enable work while seated or standing at counter
- Integrate power and network cables into structure
- Enable mounting of monitor and other devices on flexible arm supports
- Enable features that allow customization of workspace
- Integrate footrest into design of the structural element of the counter design



Figure 55
Steelcase Montage
Modular Workstation Design

Insights

- Counters at different levels for standing and wheelchair users along the counter
- Monitor mounted on flexible arm supports, makes it easy to position according to use
- Power and network raceway along linear axis of counter
- Split-level counter surface for greater flexibility in use
- Integrated storage both below and above counter

Design Specs

- Allow flexible workheight to enable work while seated or standing at counter
- Integrate power and network cables into structure
- Enable mounting of monitor and other devices on flexible arm supports
- Design split level counter to provide flexibility in use on both sides of the counter

Figure 56
Steelcase Vecta
Modular Workstation Design



Insights

- File holder and pen stand integrated in accessory rail
- Flexible vertical cable riser for power and network connections from floor
- Waste basket integrated into workstation frame
- E-box with power outlet and network nodes below the counter level
- Optional storage modules to connect to underframe

Design Specs

- Design a range of above-the-counter accessories for user to personalize workspace
- Integrate power and network cables into structure
- Integrate elements like waste basket and printer into the design of workspace
- Allow for power and network cables to connect from floor based grid systems

Steelcase System Modular Workstation Design



Figure 57

Insights

- Counter surface features a pneumatic mechanism for height adjustment
- Storage modules in both stand-alone versions and integrated systems
- Counter module separate from storage system
- Power and network cables integrated into worksurface
- Post and beam system for storage, while single column supporting countertop

Design Specs

- Incorporate a pneumatic or motorized mechanism for counter height adjustment
- Integrate power and network cables into structure
- Provide multiple storage solutions within workstation module for flexibility in use
- Define the structural system for workstation to simplify the connections and various elements of the design

Steelcase C-scape Modular Workstation Design



Figure 58

Insights

- Counter surface and storage units are separate modules
- Power and network cabling are integrated below surface
- Structural system allows the provision of a superstructure over and above counter
- Stand-alone storage units allow for more flexibility
- Vertical screens attach to counter surface creating visual partitions

Design Specs

- Design a set of storage units that allow permutations and combinations for flexibility
- Integrate power and network cables into structure
- Design connections from counter for accessories both above and below worktable
- Have provision for structural system that allows vertical elements containing lighting, HVAC systems and signage in the super-structure

Knoll Currents Modular Workstation Design



Figure 59

Insights

- Counter features pneumatic mechanism for height adjustment
- Power and network cabling are integrated below surface
- Panel system above counter allows various accessories to be attached as needed
- CPU mounted below counter with customised hardware
- Monitors mounted on a moveable arm for flexibility

Design Specs

- Allow for variable counter height to enable work in both seated and standing posture
- Integrate power and network cables into structure
- Design connections from counter for accessories both above and below worktable
- Mount monitors on flexible arm supports for users to customize monitor position according to need



Figure 60
Knoll Horizon
Modular Workstation Design

Insights

- Table surface supported by two side panels
- Power and network cabling are integrated below surface
- Frosted glass privacy panel attached to counter surface
- Storage module doubles as structural support element
- Monitors mounted on moveable arm supports for flexibility in use

Design Specs

- Design countersurfaces on both sides of central panel
- Integrate power and network cables into structure
- Design connections from counter for accessories both above and below worktable
- Mount monitors on flexible arm supports for users to customise monitor position according to need
- Integrate structural support and storage module



Insights

- Visual screens separate from structural elements
- Moveable storage units on castors for flexibility
- Above the counter storage units for easy reach
- Power and network cables integrated into vertical panel
- Table feet feature levelling screws for height adjustment

Design Specs

- Integrate power and network cabling into structural frame
- Provide visual screens as separate elements if and when required
- Provide multiple storage options in both fixed and mobile configurations
- Cantilever countertop to central post to free-up floor space below counter

Figure 62
Humanscale
Office Furniture + Accessories



Insights

- Monitor mounted to a vertical support for flexibility
- Retractable keyboard and mousepad attached to the countertop
- CPU holder mounted below the counter, reduces clutter
- Footrest with rocking motion offsets some of the negative effects of sedentary work

Design Specs

- Reduce countertop clutter by mounting devices on flexible arm supports
- Provide below the counter attachments for CPU, files, storage modules
- Build flexible footrests within the design of the counter
- Have provisions to mount keyboard, phone and other frequently used devices on flexible arms to create more useable counter space

Findings from the Precedent Analysis

The insights from the precedent study were structured into specific design specifications which are described in brief below:

1. Access

- Provide variable work height, to allow for work while seated or standing
- Provide wheelchair access on both sides of the counter
- Provide information display on both sides of the counter
- Provide for storage options both above and below the counter for easy access

2. Integration

- Integrate power and network conduits into the frame
- Integrate devices into the work surface to aide workflow
- Integrate devices into superstructure e.g., lighting, security cameras,
- Integrate body support into workspace design

3. Flexibility

- Create flexible storage modules for workspace as integrated or stand-alone units
- Allow flexibility in structural frame to allow various configurations from same kit
- Provide user's the flexibility in positioning frequently used devices
- Provide a split-level counter for users on either side of the counter

4. Structure

- Design for individual modules to connect in various configurations
- Design a mounting rail along counter length to allow attaching various devices
- Use a cantilevered structural approach for mounting counter onto frame
- Design connector mechanism for linking conduits between adjacent counters
- Allow privacy screens, storage units etc to connect to the counter top
- Provide elements to configure spaces into public, semi-public and private zones

Chapter 9: Design Thinking

The findings from the Environmental Study and Usability Study as well as the Precedent Analysis formed the basis for designing a new range of modular workspaces using the systems thinking approach. The inferences and insights from these research studies translated into design specifications which were categorised into five specific clusters - Access, Flexibility, Technology, Furniture and Environment. Each of these five clusters is discussed in detail below.

Access: The need for equitable access came across in all five workspaces that were researched. While access to a building or a public space, which has customer service counters, is mandated by the ADAAG, there are issues of access in the workspace that have to be solved through design. Our outlook on accessibility primarily focuses on abilities of people with disabilities and older adults, and the solutions proposed eschew the principles of universal design and are intended to benefit the whole population. The accessibility issues of primary concern are:

1. Provision of wheelchair access on both sides of counter
2. Provision of grab rails at check-in counters for easy luggage handling
3. Reduction in weigh scale height for luggage weighing at check-in counter
4. Provision for storage zones within the optimum reach envelope of users

Flexibility: Allowing users to customize their workspace to suit their individual needs ranked very high among users, as evidenced through our observational research and contextual interviews with staff in behind-the-counter environments. The ability to customize the physical workspace design has a significant role in improving job productivity, and several research studies have been able to quantify the benefits of improved design for task performance and comfort [25]. The flexibility envisioned in the new design is primarily about the physical workplace design, but recognizing future trends in technology (with proliferation of digital technologies), there will be need for creating flexible design solutions

that incorporate a combination of digital and physical realms. The primary issues about flexibility that we came across were:

1. Allow flexible working heights to enable work while sitting or standing
2. Design split-level counter for flexibility in use on both sides of counter
3. Allow users to customize device location according to their needs
4. Fix monitor on floating arms for flexibility in use
4. Provide flexible storage areas below and above counter
5. Provide multiple location options for printer, CPU, and other devices
6. Allow styling options to blend with the decor of the environment

Technology: The profusion of digital technologies in the workplace over the last two decades created a mismatch between the technology on one hand and the corresponding environmental design. Observational studies revealed the chaos and complexity arising from the lack of integration between technologies and physical environment. Behind-the-counter workspaces are crammed with various devices like bar-code scanners, card swipe terminals, receipt printers, cash registers, and magnetic deactivators, which are in addition to the monitor, keyboard, mouse and printers common to every workspace. Many of these devices can be integrated within the work surface to allow for a more efficient workflow. Some of the primary issues in the technology-environment domain are:

1. Position devices based on frequency of use
2. Provide for integrated cable management features in all counter designs
3. Provide multiple power and network outlets at different heights
4. Integrate devices into the planes and surfaces for a more efficient workflow
5. Combine devices to aid workflow and reduce clutter
6. Allow flexibility in design to integrate future technologies

Furniture: The dynamic nature of contemporary behind-the-counter workspaces needs responsive design strategies to encourage users to perform to their full potential in healthy, safe and enabling environments. Recognizing the need to ‘*upgrade*’ the design of workspaces in context of the massive influx of digital

devices and technologies, integration many of these technologies into the environmental fabric is proposed. The underlying theme is to use design as the strategic tool to '*tame*' the complexity that surrounds our gadget-encumbered workspaces and create meaningful solutions that allow the user to be in-charge. The observation and interviews reveal some specific instances of design integration that will merge technologies and environment to aid the user.

1. Integrate devices within furniture
2. Integrate monitor within countertop
3. Integrate demagnetize barcode scanner (Library Counter)
4. Integrate customer display and bar-code scanner (Airport Check-in)
5. Integrate body support with counter
6. Provide small ledge for hand-held items
7. Provide vertical supports for overhead display
8. Provide book racks that angle upward (Library Counter)
9. Provide space at floor level for foot rest

Environment: The design of workspaces cannot be done in isolation, without understanding their context in the macro environment. Research reveals that the degree of enclosure and the layout of workspaces has the greatest impact on work performance [27]. Consequently this design of behind-the-counter workspaces focus on modularity and inherent flexibility of the workspace. Some of the features resulted from interactions with current users during the research and a few were inspired from precedents in office workstation designs. The specific features that were incorporated into the final design are:

1. Provide for a range of shapes on the same structural module
2. Allow a range of geometric configurations or layouts
3. Allow privacy screens if required
4. Design superstructure to carry lighting HVAC, security cameras, etc

Feature	Airport	Hotel	Library	CoA Office	ID Office	Registration
Monitor	•	•	•	•	•	
Keyboard	•	•	•	•	•	
Mouse	•	•	•	•	•	•
CPU	•	•	•	•	•	
Laptop						•
Printer	•	•	•	•	•	•
Bar-code Scanner	•	•	•			
Swipe Card reader	•	•	•			•
De-activator for Books			•			
Flexible Storage	•	•	•	•	•	•
Lockable Storage	•	•		•	•	•
Weigh Scale	•					
Brochure Display	•	•	•	•	•	•
Phone	•	•	•	•	•	•
Chair			•	•	•	•
Footrest	•	•	•	•	•	•
File Storage	•	•	•	•	•	
Light Fixture	•	•	•	•	•	•
Trash Can	•	•	•	•	•	•
Reading Stand				•	•	
Security Camera	•	•	•			•
Grab bars for support	•	•				•
Storage Ledge in front	•	•	•			•
Variable Height Counter	•	•	•	•	•	•
Customer-side display	•	•	•	•	•	•
Split-level counter	•	•	•	•	•	•
Built-in seating	•	•	•			•
Power/Network conduit	•	•	•	•	•	•
Canopy on top	•	•				•
Interlocking modules	•	•	•	•	•	•
Privacy Screens	•	•	•	•	•	•
Mounting rail for devices	•	•	•	•	•	•
Wheelchair access	•	•	•	•	•	•

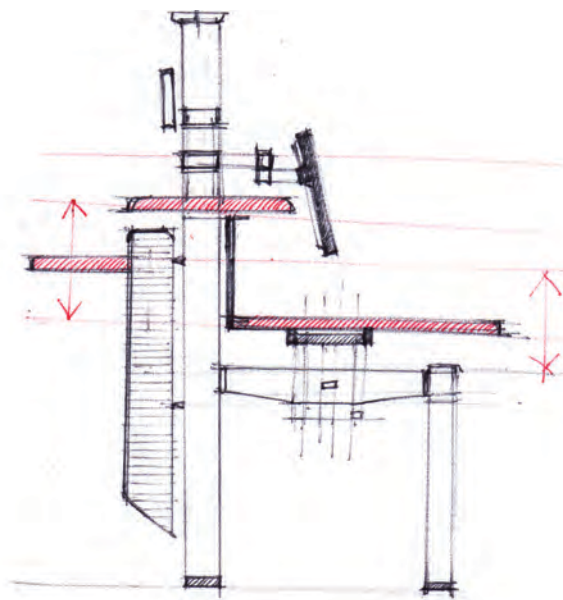
Table 2
Commonalities in Features Across Workspaces
 Creating common design specs for behind-the-counter workspaces

Chapter 10: Design Schemes

Understanding the commonalities for environmental design and work technologies enabled me to create design schemes which addressed common needs of the five workspaces. The schemes have provisions for adding-on specific features that are unique to certain workspaces (for example: the weighting scale for airport counters, or book demagnetizer for library counters). These concepts incorporate inferences from environmental and usability studies, and insights from existing office systems designs identified in precedent analysis.

Analysis of the requirements for the workspace design revealed six distinct aspects that had to be integrated into the final solution - planes, surfaces, structure, storage, technologies and environment. Planes refer to horizontal work surfaces with provisions to change heights according to the users need and posture. Surfaces in the design refer to vertical planes at the interface of the customer and staff work surfaces. Structure refers to the structural framework of the counter consisting of the horizontal and vertical elements. Integrating the variable height mechanism into the structural system was one of the prime objectives of the design. Storage modules, both below and above counter were built into the structure. Beyond the physical set-up of the counter, the design attempts to integrate work technologies into the counter surface. These technologies range from ubiquitous barcode scanners to specialized book demagnetizers that can be integrated into the furniture. The workspace is also an ecosystem and the design provides for a 'super-structure' that builds on the sense of enclosure and allows for overhead signage, lighting, security cameras and other services to be added as and when required.

The following pages highlight the genesis of the design from initial doodles to more refined sketches that illustrate various features of the design. Some of the concepts made it into the final design, while others were modified or rejected based on the feasibility of the design based on production feasibility and cost constraints.



Features

- Three level counter
- Levels move independently
- Vertical column extends
- Monitor mounts on column
- Secondary display unit
- Luminaire on column

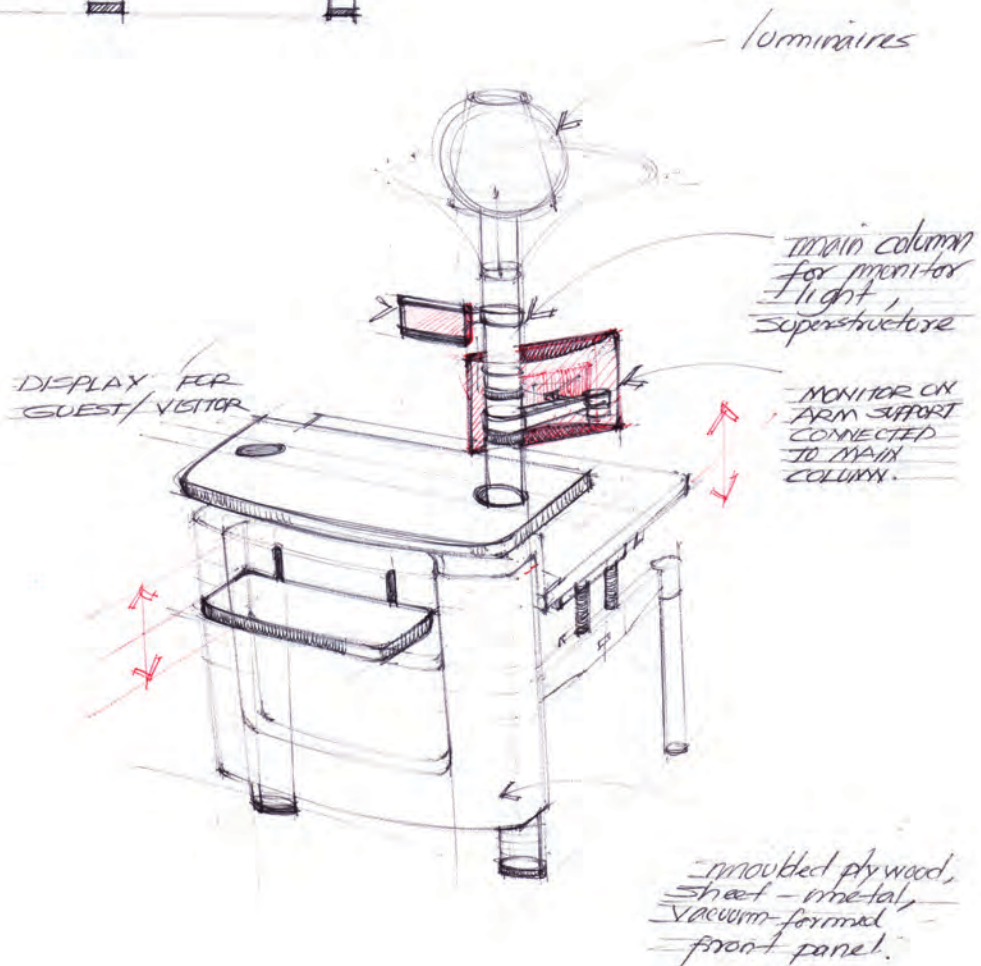


Figure 63

First Iteration : Three level counter with devices

Sketches of sectional and perspective view of the three level counter

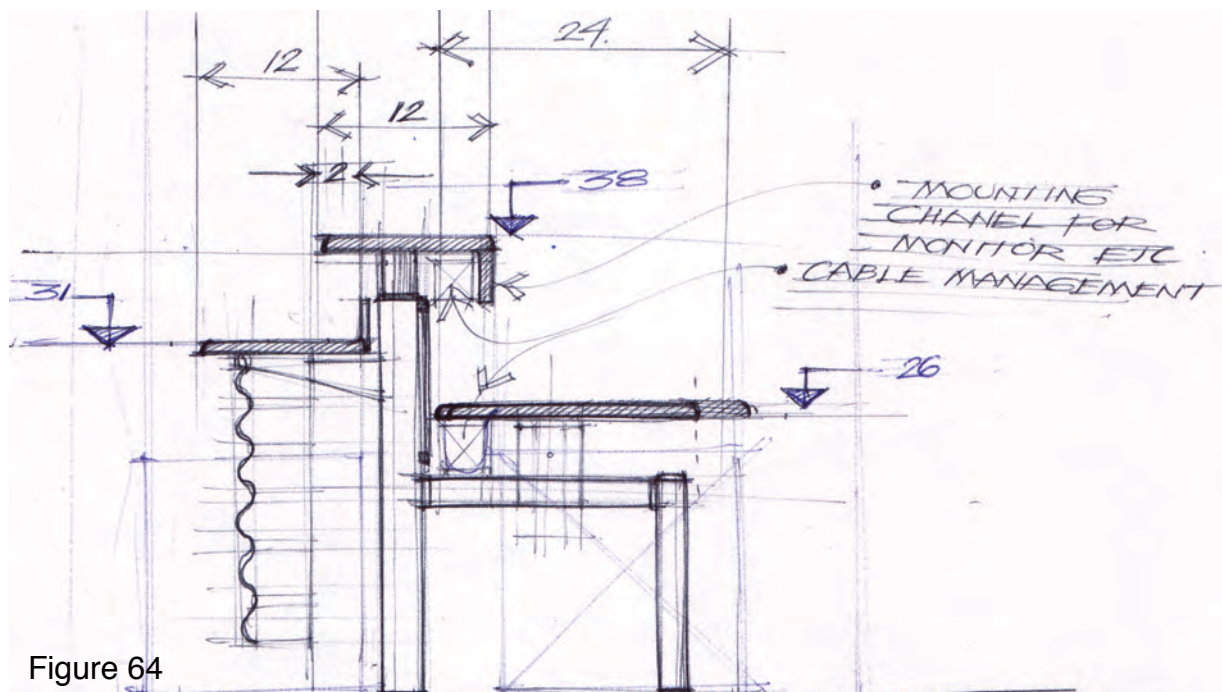


Figure 64

Sectional detail of three level counter

Minimum vertical heights of three work surfaces indicated

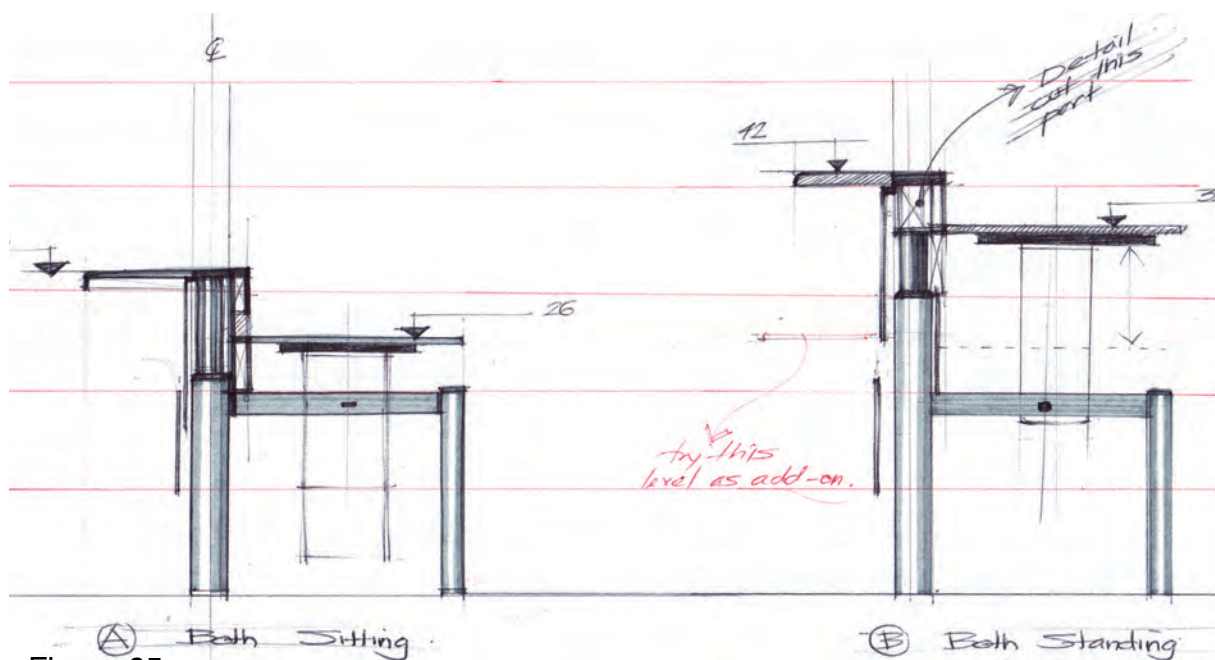


Figure 65

Sectional detail of two level counter

Showing two extreme cases : both sides sitting or standing at counter

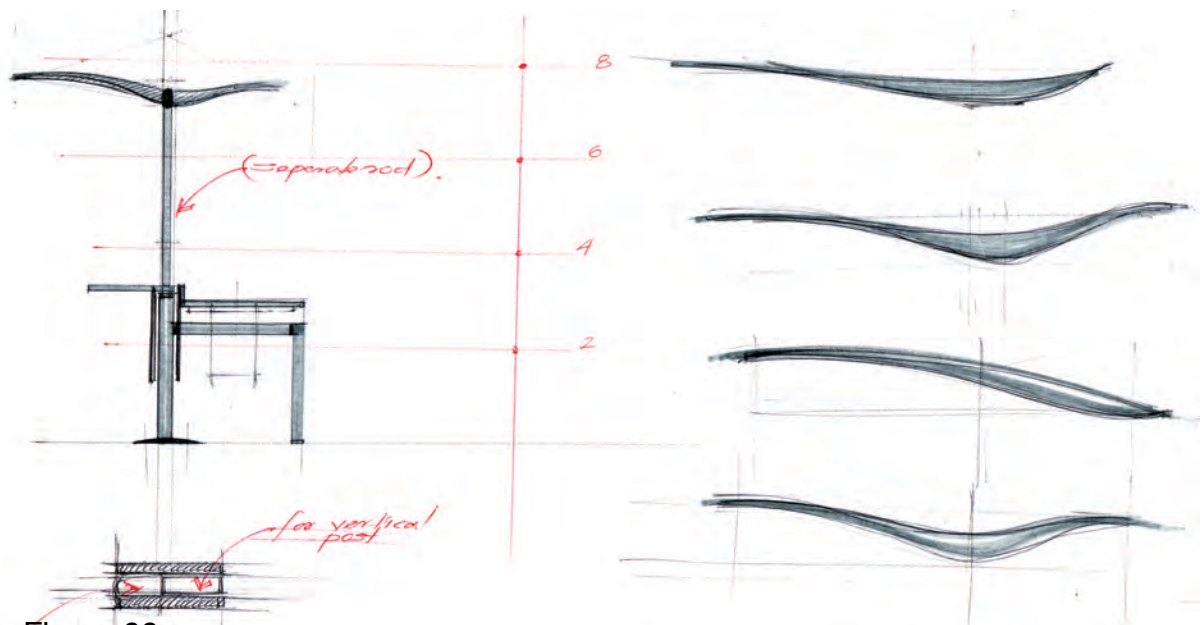


Figure 66

Sectional detail of canopy structure

Showing four variants of canopy profiles on same structure

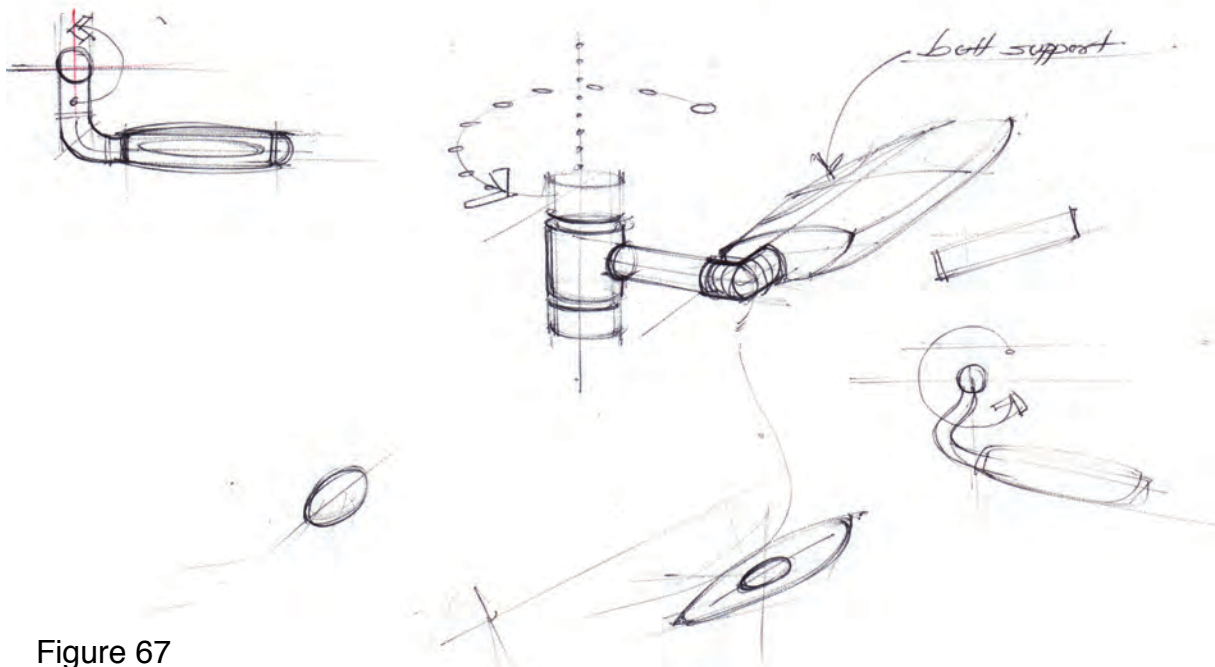


Figure 67

Concepts for body support

Body support using L-shaped member connected to frame

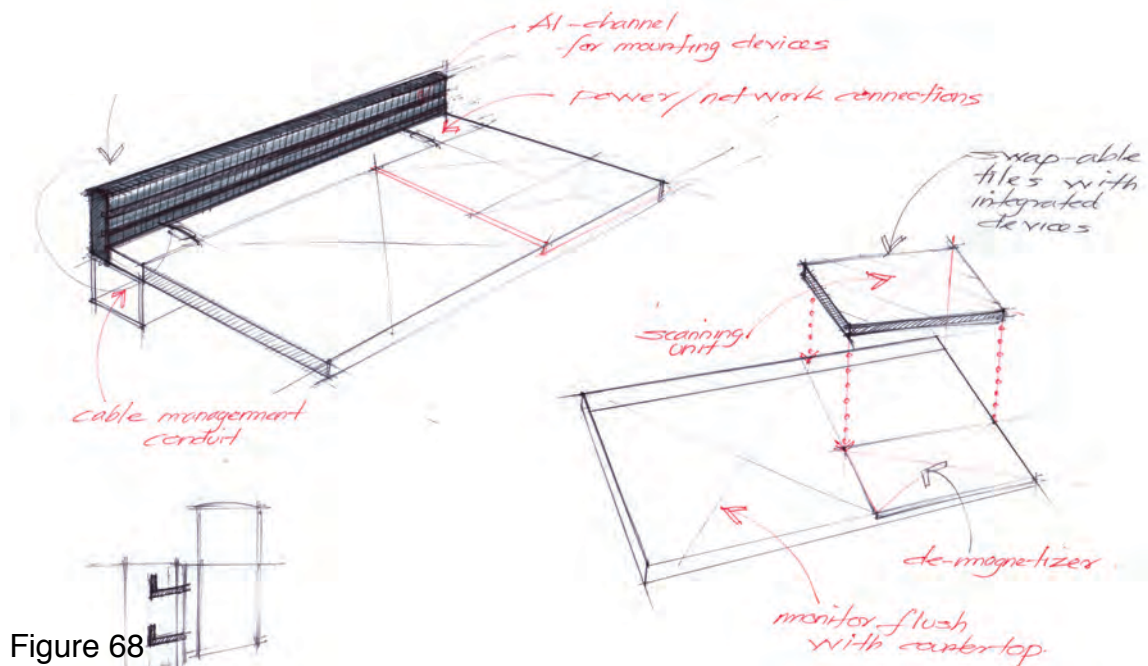


Figure 68

Worksurface with integrated technologies

Modular tiles with integrated devices, eg book demagnetizer

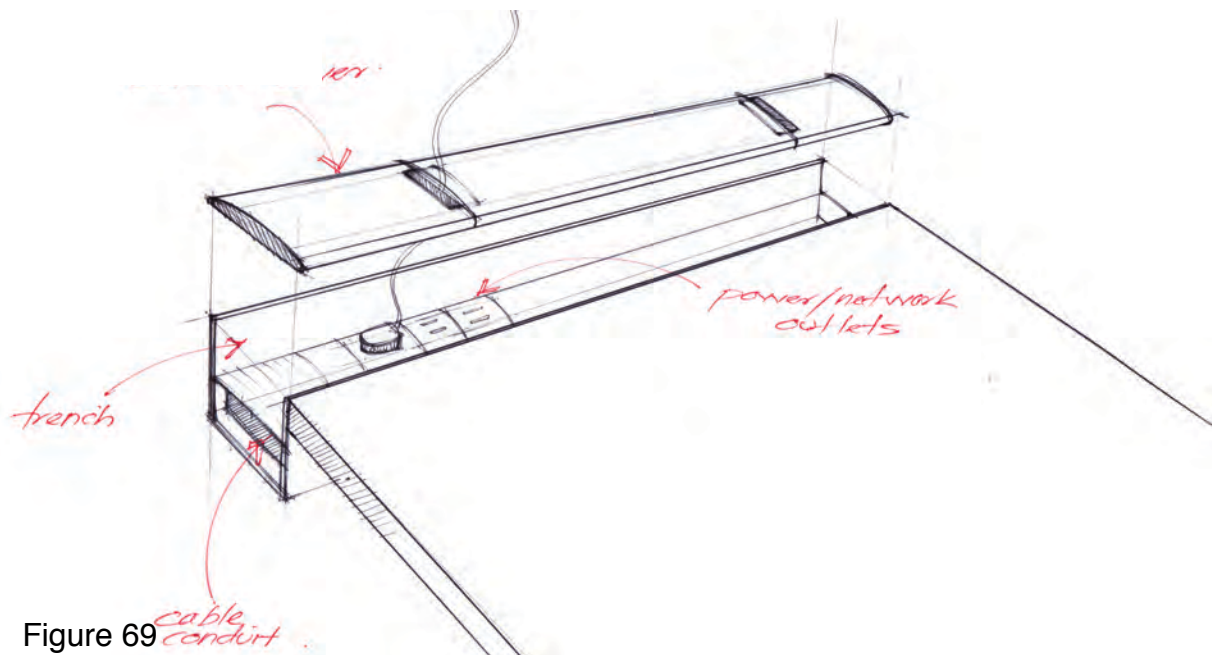
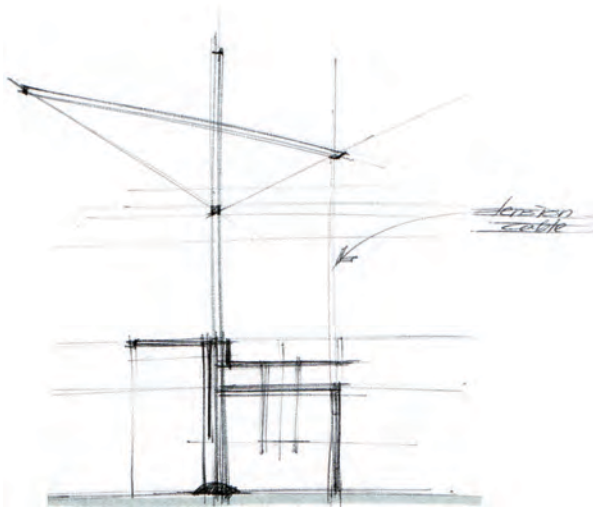


Figure 69

Cable Management System

Cable raceway below counter surface for power and network



Features

- Canopy above counter
- Indirect illumination above
- Signage mounted above
- Single/dual pole variations
- Creates sense of enclosure
- Allows for security cameras, lights etc mounted above

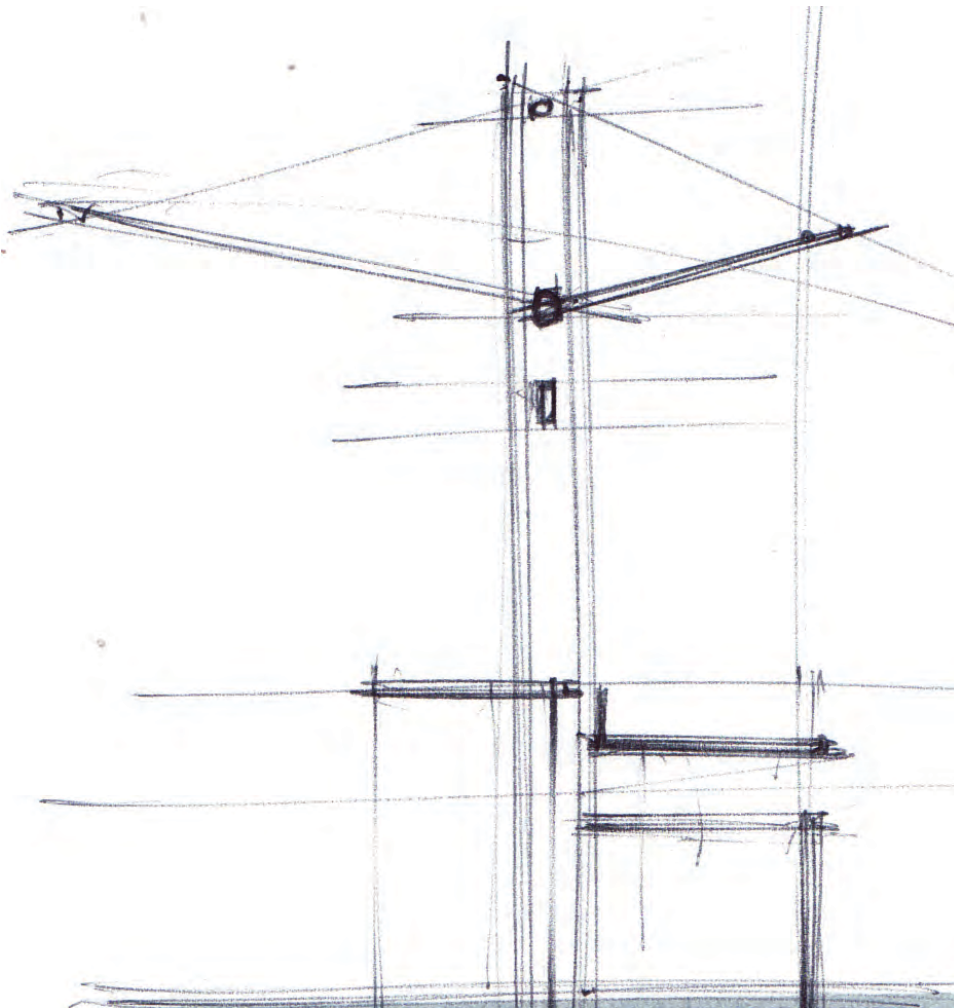


Figure 70

Superstructure providing enclosure

Sketches of different options for enclosure in public spaces

Features

- Gas assisted height adjustment
- 10" vertical travel on customer side
- 12" vertical travel on staff side
- Cable raceway below counter
- Storage module below
- Modesty panel in front

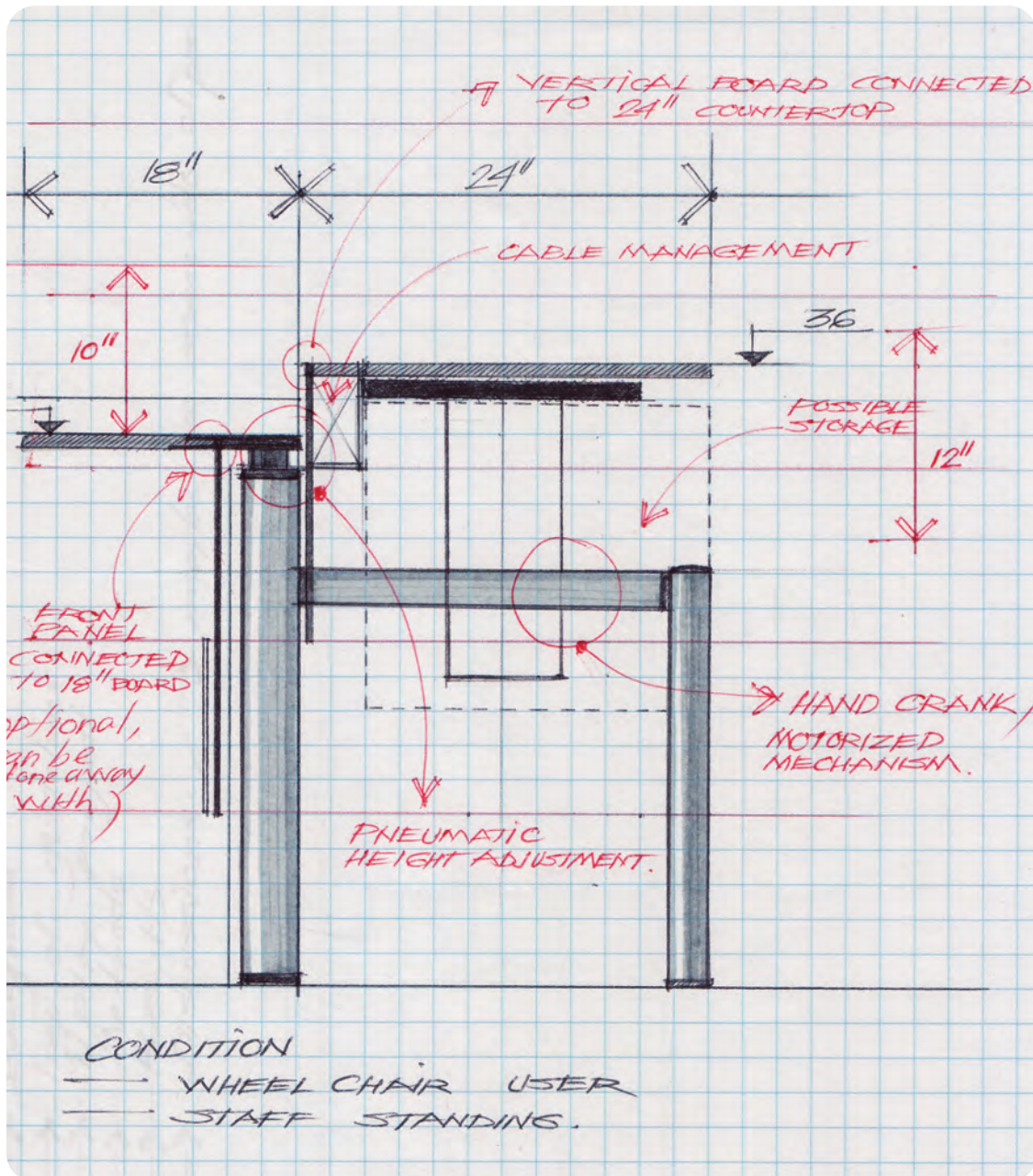


Figure 71

Detailed section view of two level concept

Dimensioned sketch of section showing vertical travel ranges

Features

- Gas assisted height adjustment
- 10" vertical travel on customer side
- 12" vertical travel on staff side
- Cable raceway below counter
- Storage module below
- Modesty panel in front

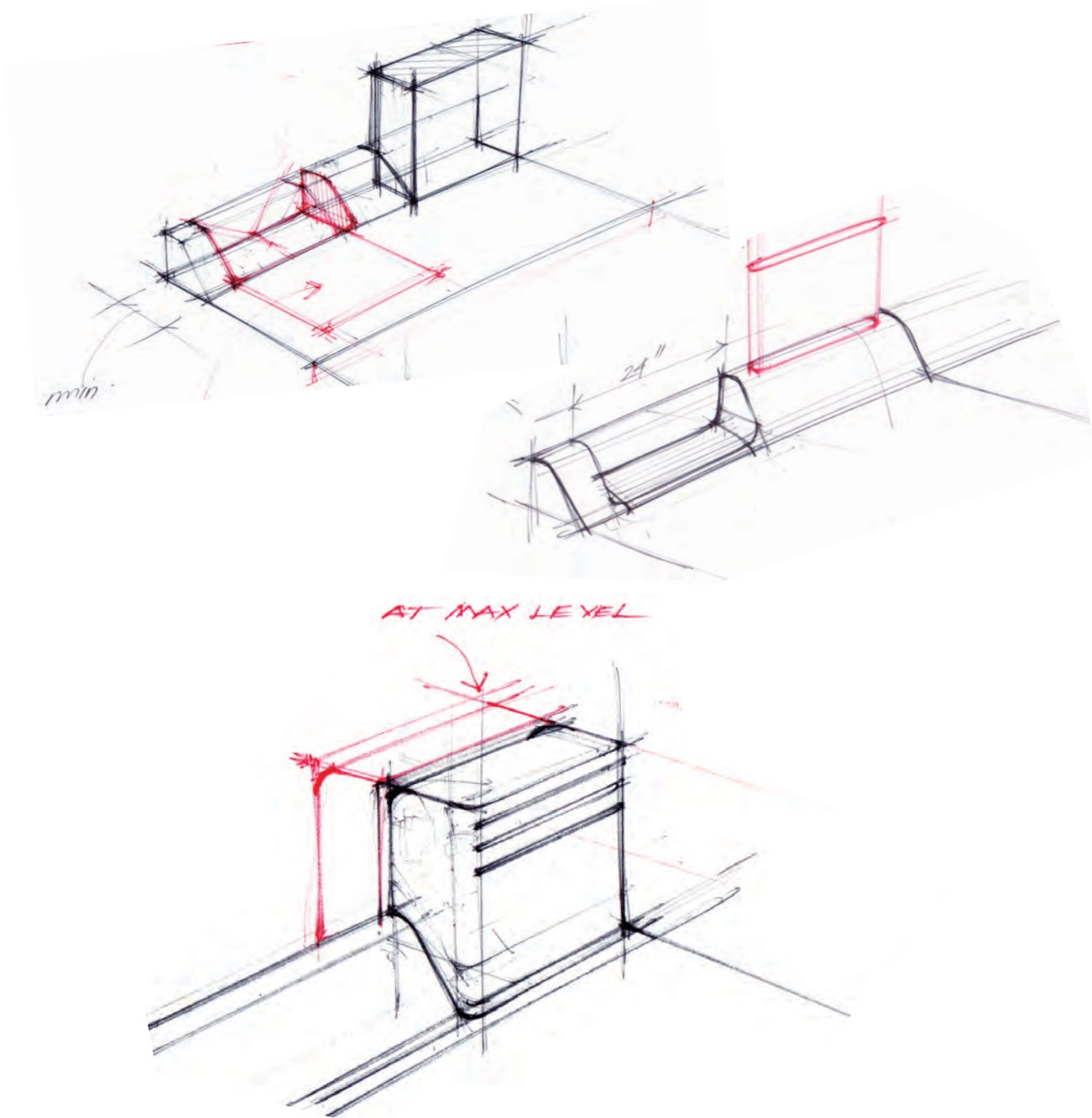


Figure 72

Concepts for device integration on countertop

Three explorations for mounting monitor and other devices

Chapter 11: Scale Models

Conceptual sketches were developed into scale models that enabled a quick and easy way of envisioning the design in three dimensions. The basic structural system for the counter with vertical and horizontal surfaces and enclosure above were created in the model. These prototypes provided a means for discussion with fellow designers and users. Responses from these informal discussions enabled refinement of the designs.

Initially a model was created for the counter with three levels - one for the customer, another for staff and the tallest level in the middle (Figure 73). The customer level and the middle level were linked so that they moved up or down together while the staff counter moved independently of other two surfaces. However, the utility of the middle level did not justify the complexity of the design. The next model (Figure 74) featured only two levels - recognizing the redundancy of the middle level. This resulted in a simplified structure consisting of two h-shaped members connected by a longitudinal member. The gas assist mechanism for raising or lowering the surfaces was integrated into the structure.

The third model (Figure 75) is a linear pattern of three counters along with an overhead enclosure. The three counters exhibit different possibilities of the variable counter height - (a) both sides sitting, (b) customer sitting / in wheelchair and staff sitting / in wheelchair, (c) both sides standing. The enclosure above (referred to as the superstructure) is connected to the counters by horizontal members to create one unified linear arrangement. The following pages show the scale models and describe important features of the respective concepts.

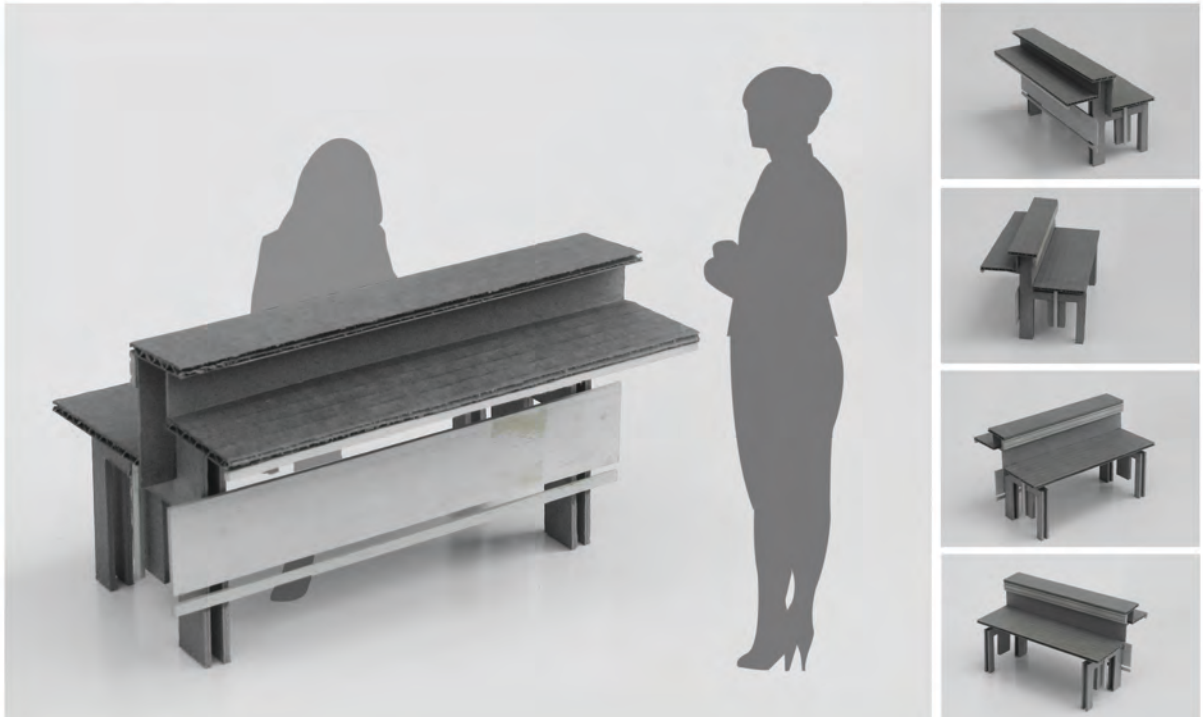


Figure 73
Scale model - three level counter



Figure 74
Scale Model - two level counter

Features

- Enclosure above counters
- Both sides standing (a)
- Both sides sitting (b)
- Customer sitting, staff standing (c)
- Wheelchair access on both sides
- Enclosure relates to human scale

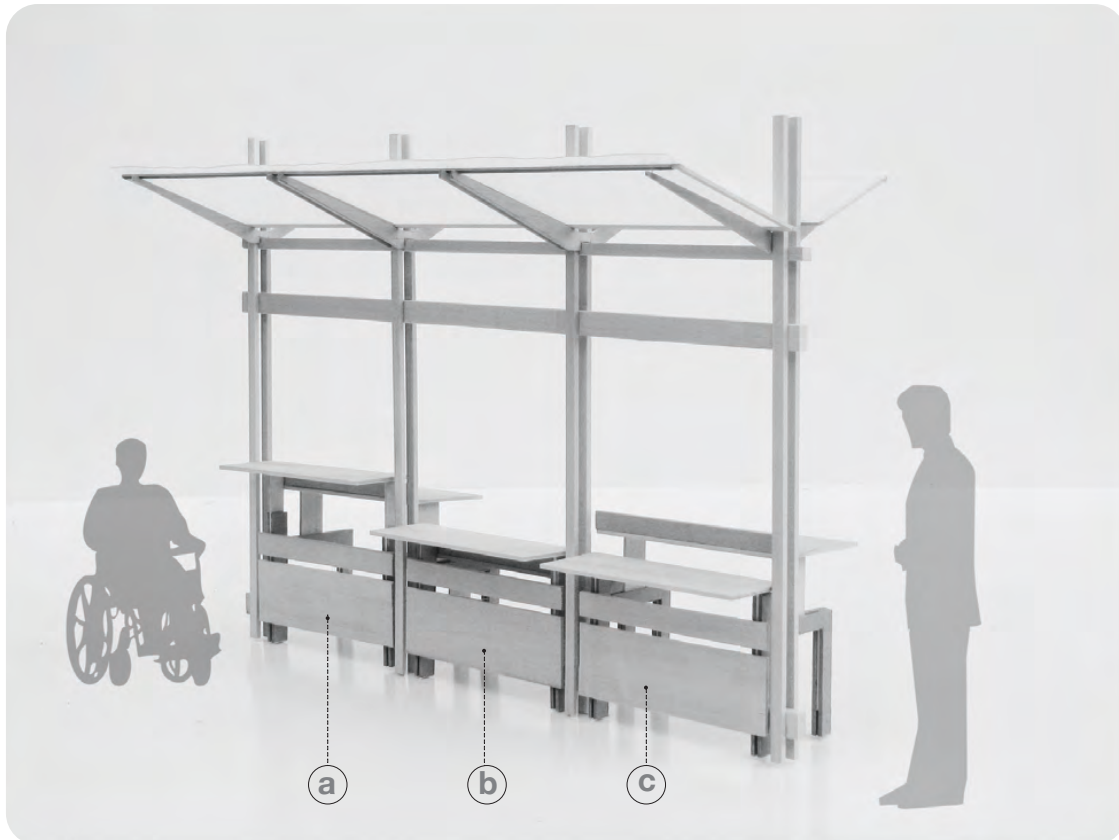


Figure 75

Scaled model with enclosure above

Front and rear perspective view of counters in linear arrangement

Chapter 12: Final Scheme

The final design was digitally created in a CAD Modeling program which allowed accuracy and rapid visualization of the concept. Integrating the commonalities and basic features identified earlier, a standard workspace was designed. This model became the basis for the Hotel, Library and Conference reception counters. Both counters feature variable work height enabling work in seated and standing postures (including wheelchair access on both sides). Critical dimensions like work heights and counter width were determined from anthropometric data studies [29, 30] and ADAAG guidelines [23]. Common features included storage counters below, monitor on floating arms, a ridge at the staff counter edge for integrating frequently used devices, card reader at both customer and staff sides. Specific features like a book demagnetiser or a bar code scanner could also be easily integrated into the surface.

For the office reception counter, a storage module was added to the original counter, recognising the need for greater storage space. This created a L-shaped configuration for the office counter, and the design provides for an additional storage counter if the need arises. Further, the modules enable vertical additions to meet the growing need for greater storage needs in contemporary offices. Also a printer tray with easy access for the staff working at the counter was included in the design. The modular design allows for parts to be easily swapped, and results in a wide range of permutations and combinations from a limited set of parts.

The airport check-in counter features the standard module with the addition of a weighing scale. It also features integration of specific features like weighing scale displays on both sides, boarding pass and luggage tag printers. The modularity of the design enables integration of future technologies into the workspace and allows users to customize the space according to their own preferences. While the designs are shown as separate or island units, they can be combined in linear or circular configurations if the need arises. The sectional detail and renderings follow:

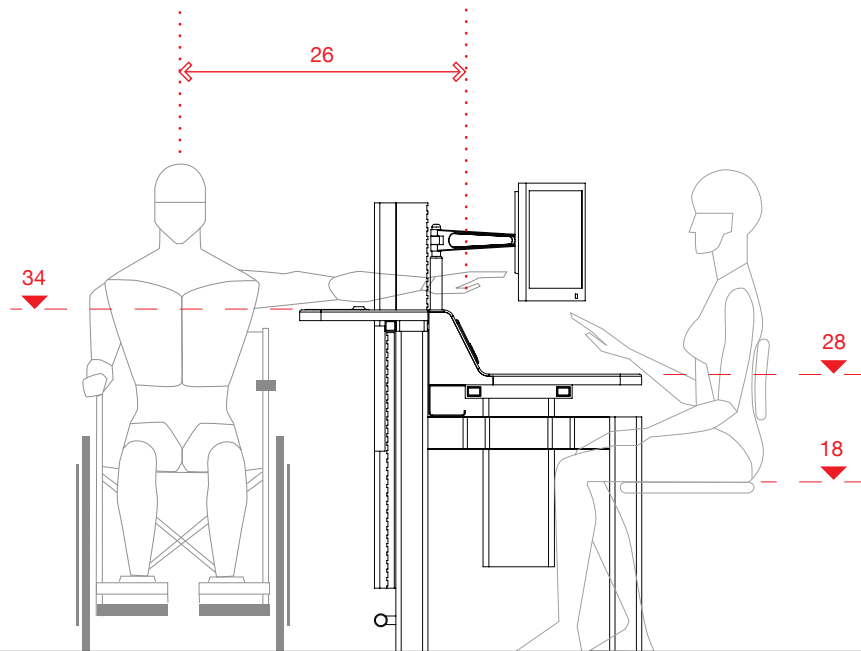


Figure 76

Different modes of work at counter

Customer in wheelchair and staff seated at counter

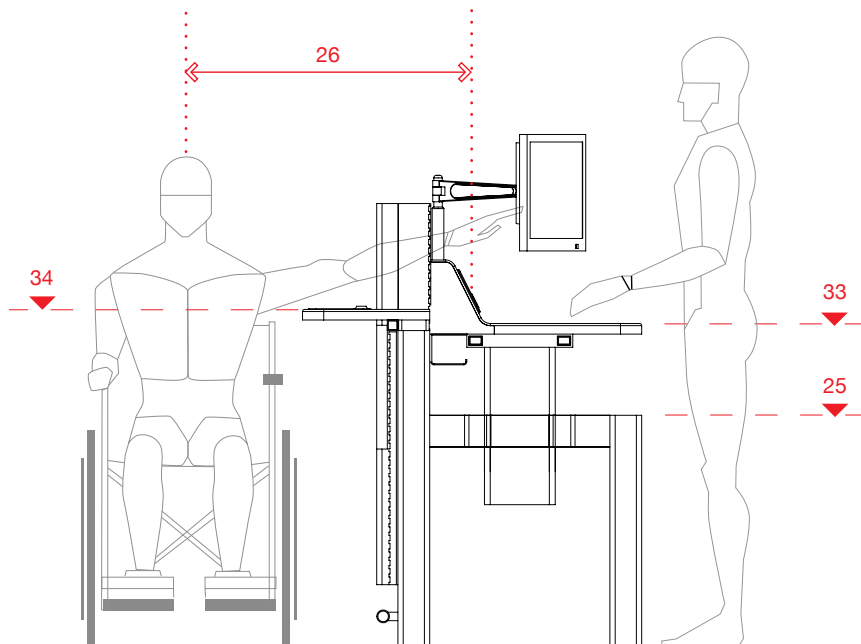


Figure 77

Different modes of work at counter

Customer in wheelchair and staff standing at counter

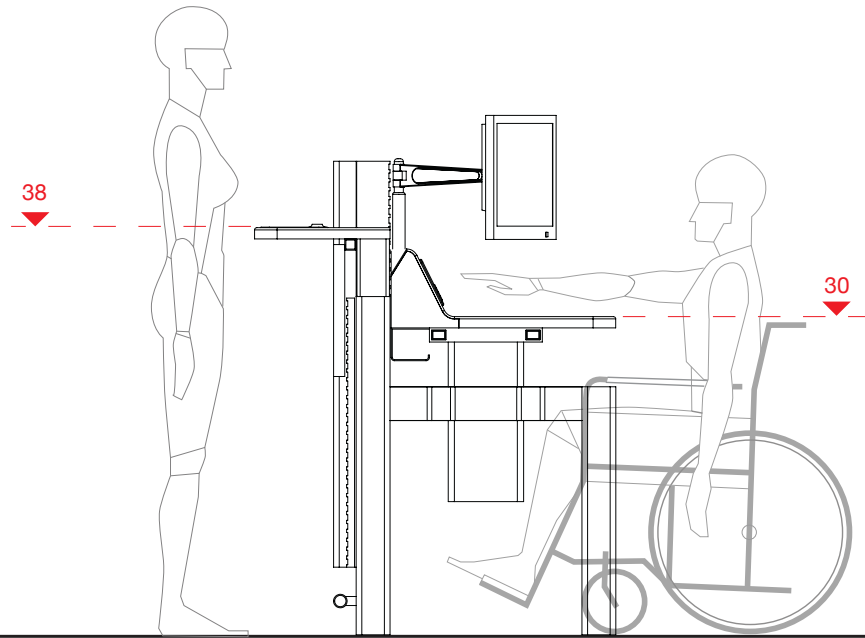


Figure 78
Different modes of work at counter
 Customer standing and staff in wheelchair at counter

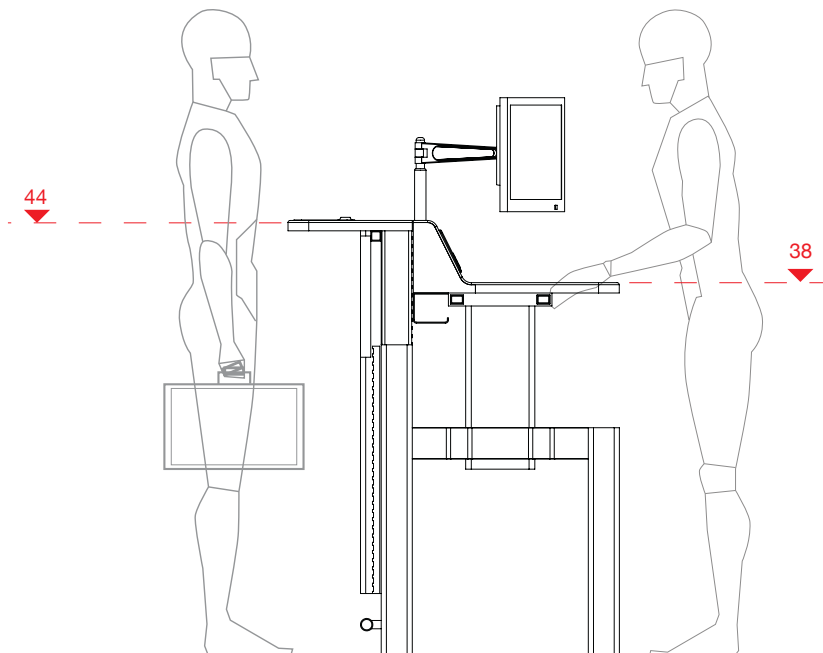


Figure 79
Different modes of work at counter
 Customer standing and staff in wheelchair at counter



Features

- Variable height counters
- Monitor on arm supports
- Grab bar integrated into counter
- Storage modules below counter
- Bar code scanner provided
- Demagnetizer integrated
- Card reader built in
- Garbage can integrated
- Cable raceway below counter
- Finishes and materials can vary



Figure 80

Counter for Library / Hotel / Conference
Front and rear perspective views with features



Figure 81
Counter for Library / Hotel / Conference
Modes of operation - wheelchair accessible on customer side

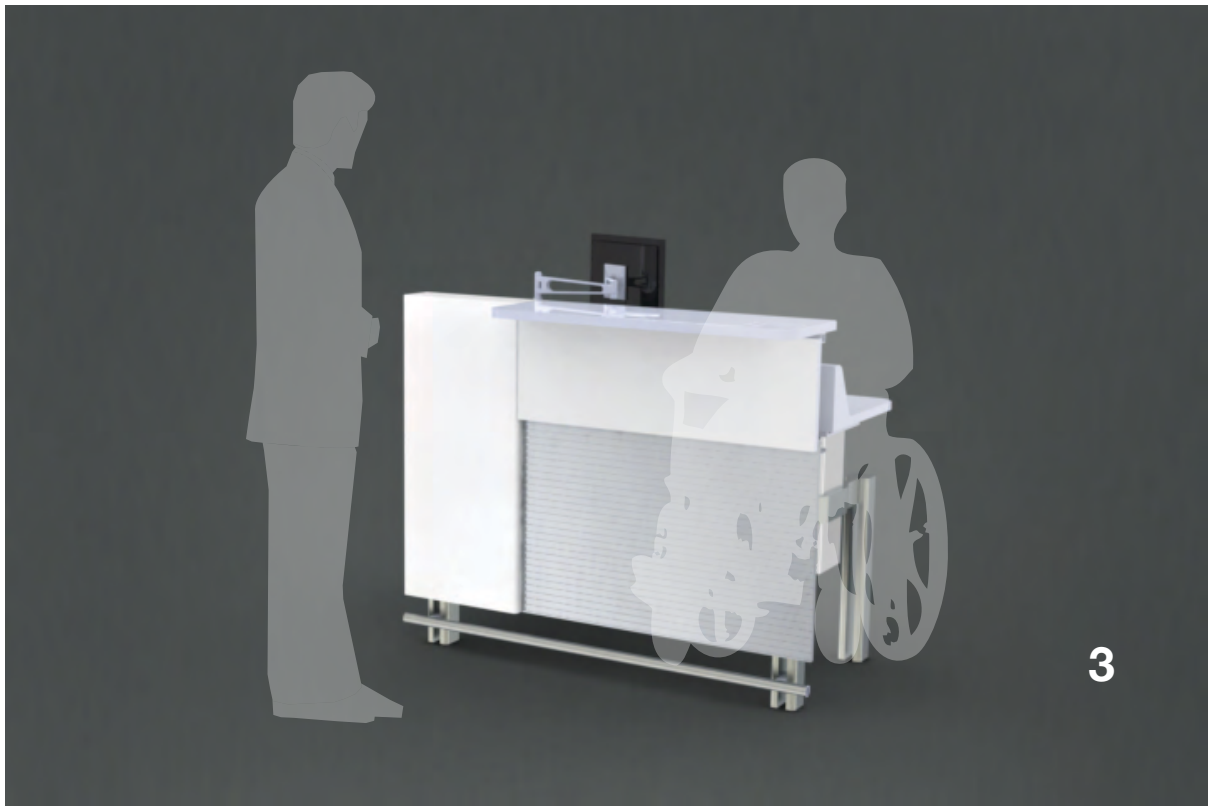


Figure 82
Counter for Library / Hotel / Conference
Modes of operation - wheelchair accessible on staff side

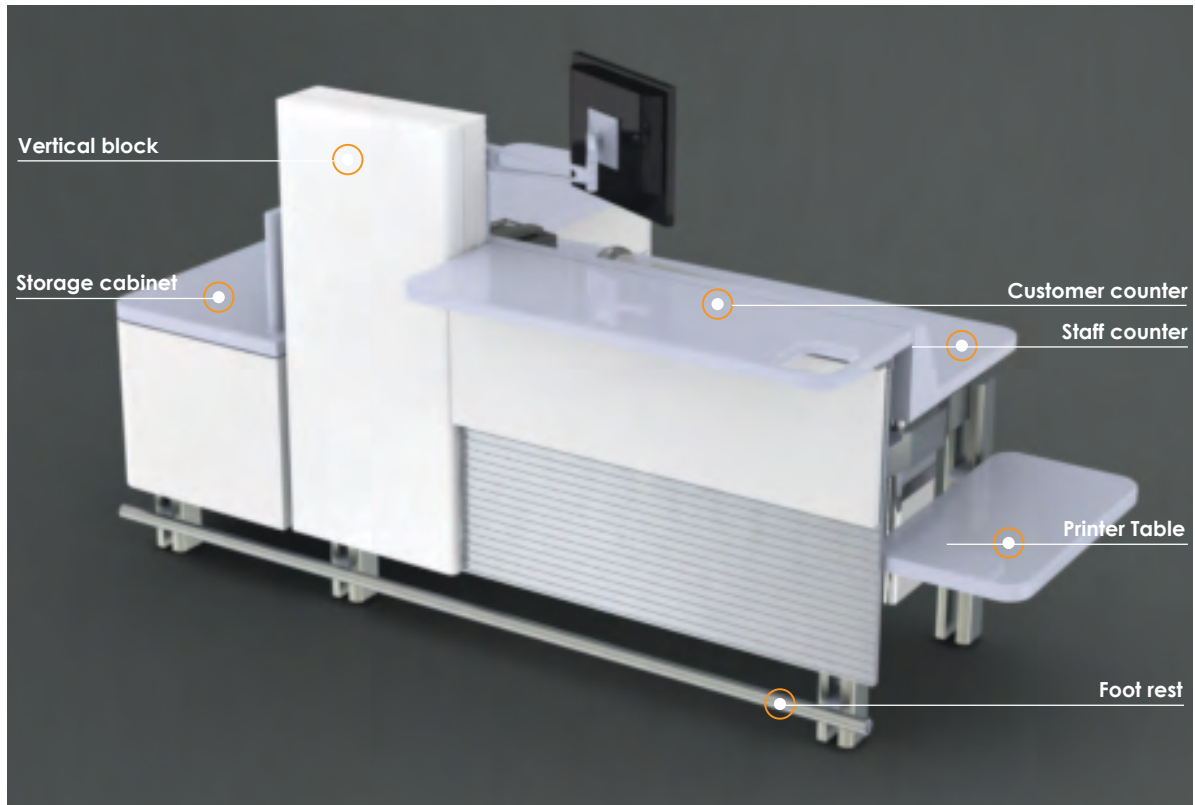


Figure 83
Counter for Office Reception
Front and rear perspective views of the counter

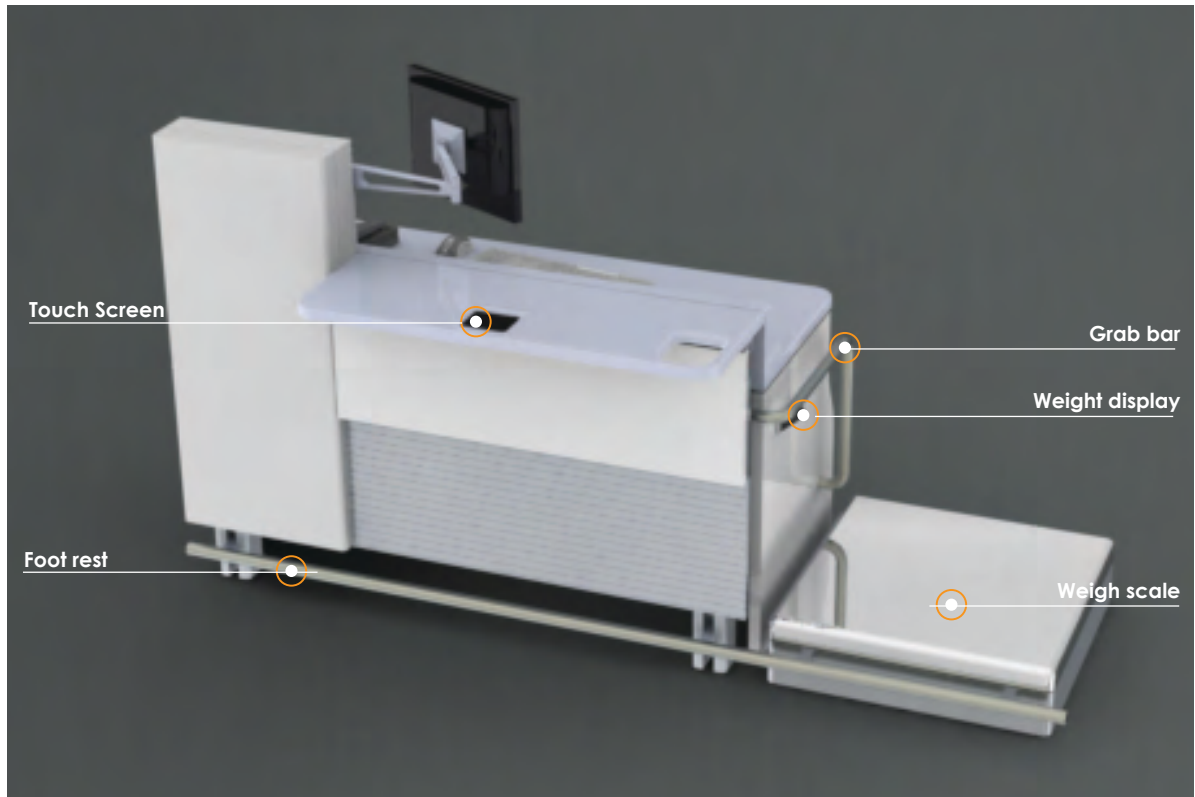


Figure 84
Counter for Airport Check-in
Front and rear perspective views of the counter

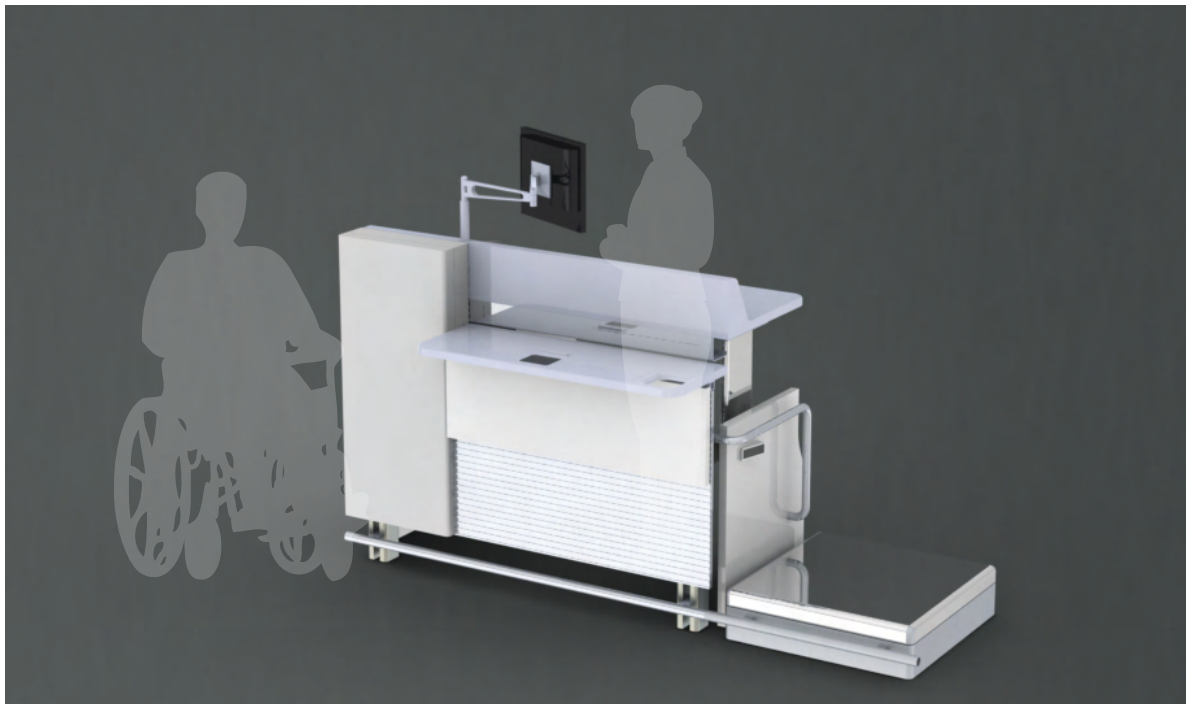


Figure 85
Counter for Airport Check-in
Different modes of operation including wheelchair access for customers

Chapter 13: Feedback

The final designs of the reception counters were shown to behind-the-counter professionals working in office reception counter, library counters, hotels and conference reception counters. Airport check-in counter staff were also contacted for their responses on the design, but bureaucratic hurdles meant that their responses were absent from the design review. In total, feedback were received from fifteen respondents and their suggestions are provided in the following pages. Requisite Institutional Review Board (IRB) approval was obtained before the process of requesting user response was initiated.

The process of getting feedback started with creation of a questionnaire explaining features of the design, modes of operation and variations for specific occupational needs. After going through designs in the questionnaire participants had to answer questions regarding the design. These questions were -

- (a) *What were the strengths of the design?*
- (b) *What were the weaknesses of the design?* and
- (c) *Any suggestions for improvement?*

This questionnaire was given to behind-the-counter professionals in office receptions (2), hotels (4), conference facilities (4) and library counters (5). All locations for the post-design feedback were the same as the one's in which I had conducted the environmental and usability studies. In two of the locations, the office reception counter and library, feedback was provided by the same people who had taken part in the usability study six months earlier. People working in behind-the counter workspaces were excited to see the final designs and provide feedback. Recognizing the busy nature of their work behind the counter, users were briefed about the questionnaire and given one working day to answer the three questions. The process of sending out questionnaires and receiving feedback from the users lasted a week. Besides written responses from the participants, informal interview responses during the briefing process were also taken into account while compiling the final responses.

1. What do you feel are the **strengths** of the design?

- Allows people with disabilities to work at counter
- Adjustable counter height for work while seated or standing
- Monitor on floating arm support for flexible positioning
- Integrated devices give a clean and professional look
- Foot rest for the customer side
- Designated locations for usual items like pens, paper clips reduces clutter
- Providing more useable workspace
- Flexibility in design allowing users to customise position of devices
- Service at different heights
- Wheelchair access on both sides of the counter
- Multiple locations for CPU, Printer scanner etc
- Ability to sit or stand and maintain eye contact level
- It works for everyone

2. What do you feel are the **weaknesses** of the design?

- Initial installation can be more difficult
- How the height is changed, who decides and where are the controls
- How quickly can the heights be changed
- Have doubts about the reach ranges over the counter
- Ridge on staff side of counter can hinder in transaction of books etc
- Need for more counterspace to deal with increased volume of transactions
- Integrating devices in surface could be counterproductive in rush hours
- Provision of a hand held scanner to supplement surface integrated scanner
- Feel that maintenance/repair of integrated devices may be more time consuming
- How does the design adapt to newer technologies
- The counter space for staff needs to be wider to accommodate multitasking
- Storage zones seem less than optimal for office reception work

3. What are your **suggestions** for a better design?

- Workspace needs to be wider to accommodate larger projects
- Monitors on customer side for patrons to see
- Multiple scanners or demagnetizers to cope during rush hour
- Integrated sign holders in front of desk
- More storage areas with provisions for books, laptops cameras etc
- Eliminate ridge on staff side and provide a flat surface for easy transaction
- Add wheels to base for easy mobility
- Provide options to customise the look to blend with environmental design

Table 3

Feedback from behind-the-counter staff

Strengths, weaknesses and suggestions from users

Analysing feedback from users provides us with a balanced response about the successes and failures of the design. Most users appreciated inclusive features in the design that allow people with disabilities to work in behind-the-counter workspaces. The one feature appreciated by almost all the respondents was the ability to change counter height to enable work while seated or standing. The flexibility in layouts and arrangements of devices as well as the ability to customize workspace were well received by users. Having the monitor mounted on floating arms was appreciated, and basic idea of integrating devices into the counter surface was commended by most respondents.

While users appreciated the idea of integrating devices into furniture, their responses suggest that the manner of integration and positioning of devices within the work surface need further study. Library staff raised concern about the surface integrated bar code reader because most books have the bar code on the inside and this would complicate the check-out process. Their suggestion was to have a hand held scanner supplementing the counter integrated version. Also, users voiced concern for greater storage space and for wider counters. The ridge on the staff counter integrating devices and controls was perceived to be a barrier for book transactions. Users raised questions about the location of the height controls and the time required for changing the counter height. Some of these perceived weaknesses of the design can only be tested and refined by building full scale prototypes and testing them with users.

Suggestions from users ranged from broad overarching ideas to specific design changes. Users wanted wider workspace counters and more storage space. Counters with wheels for easy movement, variations in surface materials and finishes, separate monitors for customers were other popular suggestions which can be easily integrated into the design with a few modifications. The basic module is flexible and adaptable enough to accommodate most of the suggestions.

Chapter 14: Evaluation with UD Checklist

At the outset of this project one of the primary goals was to create a range of universally designed solutions for behind-the-counter workspaces. Now, with the design process having undergone a full cycle of development, it is important to cross check our solutions with the principles of universal design. The guidelines provide a filter for accessing the success of the project from a universal design perspective. This project provides a case study for understanding the challenges of adopting a universal design approach in a specific context, and the successes and potential barriers thereof. It is also a point of reference for future work in this domain.

The solutions are placed in context of the principles of universal design to provide an understanding of how they tie in with the philosophy of universal design and highlight areas where more effort needs to be applied. The open-ended nature of the guidelines leaves room for interpretation and allows individual translation of information. The solutions should be viewed as not a means to an end but as a way forward. The seven principles of universal design are given below and specific design solutions that address each one of them is discussed.

Principle 1: Equitable Use

The design is useful and marketable to people with diverse abilities.

- Separate counter space for customer and staff
- Variable height of counter for seating and standing use
- Wheelchair access on both the sides of counter
- Information display on both sides
- Transaction devices on both customer and user side
- Avoids segregating or stigmatising any users
- Built in provisions to vary levels of privacy according to specific needs
- Grab bars for easy handling of luggage transactions

Principle 2: Flexibility in Use

The design accommodates a wide range of individual preferences and abilities.

- Provision to work while seated or standing at the counter
- Ability to reconfigure space and devices for right/left handed usage
- Monitor mounted on flexible arm supports
- Mouse, keyboard positions are flexible
- Storage space can be reconfigured as required
- Modular design is inherently flexible, offering users to customize the workspace

Principle 3: Simple and Intuitive Use

Use of the design is easy to understand, regardless of the users experience, knowledge, language skills or current concentration levels.

- Eliminates 'device clutter' by integrating technologies and devices into furniture
- Spatial design and device placement based on workflow

Principle 4: Perceptible Information

The design communicates the necessary information effectively to the user, regardless of ambient conditions or the user's abilities.

- Product semantics are consistent with user's prior experiences at work
- Mobile and static elements are differentiated with materials and color
-

Principle 5: Tolerance for Error

The design minimises hazards and adverse consequences of accidental or unintended actions.

- Moving parts and mechanisms are encased and have fail safe features
- Corners and edges of counters and surfaces are filleted
- Spatial design potentially reduces occupational health injuries

Principle 6: Low Physical Effort

The design can be used efficiently and comfortably and with minimum fatigue.

- Variable height allows user to customize working height according to stature

- Pneumatic action for height adjustment reduces physical effort
- Work zone and storage in optimal reach envelope reduces overextension
- Body support (when standing) reduces sustained physical effort at work
- Layout optimised according to workflow minimises repetitive actions

Principle 7: Size and Space for Approach and Use

Appropriate size and space is provided for approach, reach, manipulation and use regardless of user's body size, posture and mobility.

- Clear line of sight for user over important elements while seated or standing
- All devices, storage and work surfaces are in the optimal reach envelope
- Flexibility in design accommodates variations in height and reach
- Wheelchair access on both sides of the counter

Chapter 15: Conclusions and Future Work

From this research, several potential design features which could empower older adults and people with disabilities to work in behind-the-counter workspaces were identified and refined with user feedback. These measures increase employment possibilities for these under represented groups by reducing physical barriers to work for those with functional limitations. After analysing data from usability study, environmental study and precedent analysis, workstation height adjustment became a priority since the workforce population measurements would vary greatly from user to user. Features like variable height surfaces on both sides of the counter allows users to work while seated or standing as well as promotes accessibility to wheelchair users. This maximises independence and participation of diverse individuals and provides optimal accommodation for a constantly shifting workforce. Other features like component placement within an optimal reach envelope provides for a comfortable work environment, reduces work related injuries and physical job demands. In addition physical and cognitive demands are reduced by integrating work technologies into the physical fabric of work environment and distributing certain tasks between the counter staff and the customer.

The universal design checklist for design of behind-the-counter workspaces complied during this project, not only provide a useful and practical framework for new behind-the-counter workspaces, but also serve as an evaluation tool for current customer service counter designs. Primary goals of universal design such as equitable use and flexibility in use were addresses by providing increased accessibility through accommodations of standing and seated users including wheelchair users. Another aspect of the universal design guidelines is to reduce physical effort. Task demands and injuries associated with current counter workspaces were analysed and key factors identified to provide efficient solutions that eliminated or reduced bending down or over extension during work. Other aspects of universal design like simple and intuitive use were particularly

important for streamlining the transaction process and reducing time and effort for users on either side of the counter. Integrating technologies into the physical infrastructure enables efficient usage of space and enhances across the counter communication. Eliminating a multiplicity of devices and providing locations for devices based on workflow speeds up the work and allows for a more intuitive and consistent interaction with the user. Changes in the customer service work, driven by social and economic factors generate the need for more universally designed service counter designs. Given the demographic projections for the coming decades, the relevance of such designs that cater to basic and extended needs of people with a diverse range of abilities is going to be increasingly relevant.

Results for this research show that addressing users and corporate needs towards a common goal of creating universally designed behind-the-counter workspaces is not an easy task. The initial level of investment in the design will prove to be financially viable by reducing long term costs due to reduced injuries at work, lower occupational health implications and increase in productivity attributed to improved workstation designs. The modular approach allows for the same set of parts to recombine and reorganise to adapt to the changing needs of the service environment. Beyond the financial argument, the design allows for a more equitable and accessible approach to work which will be appreciated by all stakeholders. With this framework of shared benefits and value, this project intends to have an impact on the customer service industry by illustrating the potential for design research and universal design in addressing the future challenges of customer service workspaces.

Reducing attrition rates for customer service workers was perceived to be a major corporate need. Culturally and economically, staff in behind-the-counter environments deal with high physical demands during long hours behind the counter. However, low wages as compared to other industries and lack of societal recognition for their services mean that such jobs are of a temporary nature and

have a significantly high rate of attrition. A universally designed workstation for counter work that provides better working conditions for employees should encourage staff retention. Also the universal design approach can increase accessibility and reduced cognitive and physical demands in work flow, while widening the employment pool and enabling people with functional disabilities to consider these jobs as a long term career prospect.

Looking back at the design questions behind the research, there are definitive answers to some of them, while others need validation with full scale testing of prototypes in the real world scenario. In response to the first question about the universal approach to designing behind-the-counter workspaces, the study and design outcomes have been fairly successful in proving that a modular design approach incorporating the principles of universal design can be successful in this context. The modular design allows for customization according to individual needs and the universal design principles enable designs to be accessible to older adults and people with disabilities. The second question tries to address the issue of modularity in greater detail. The aim was to understand the commonalities for workspace design, layout and features among the five different professions and then create a basic module which addresses the common needs. The human-centered design methods were successful in identifying commonalities, and building a viable modular solution that could meet the minimum needs of the five professions. The third question seeks to understand the successes and failures in the current human-environment interaction by the adoption of research methods to determine 'environmental fit.' The research was successful in identifying causes of lack of 'environmental fit' in all the five workspaces, and the proposed solutions seek to address the problem from a human-centered perspective. However, the concepts need to be built into full scale working prototypes that have to be tested with older adults and individuals with disabilities to validate the success and launch the designs commercially. The fourth question seeks to create a range of customizable features that allow individuals to organize and personalize workspaces according to their needs and

preferences. In this respect, the design offers some conceptual solutions in terms of flexibility in positioning devices and customizing the look and feel of the workspace. However, these concepts have to be transformed into fully resolved prototypes and iteratively tested with users to validate the designs and successfully answer the design question.

As a conclusion, this project shows that universal design philosophy in combination with human centered research methodologies can create equitable, accessible, empowering solutions that benefit both society and positively affect the corporate bottom line. The adoption of a modular design strategy, by borrowing ideas from office system designs, allows for a range of design possibilities that can permeate across a various professions the require customer service environments. Also use of user feedback loops at stages of the design process led to insights and inferences that proved to be an effective way to iteratively validate our ideas with end users. While the final design schemes explore a particular approach to the problem space, the intervening research allows for a rich matrix of design possibilities that are yet to be explored.

Future work for this project should include a broader range of service environments. Also a deeper look into the needs of customers on the other side of the counter is a priority. Collaboration with technology suppliers and retail, commercial and institutional customer service providers is imperative to refine the design and explore challenges for manufacturing and installation. The next level of the project should be the creation of functional prototypes and subsequent installation in real workspaces. While much of the research data used to create the designs and guidelines comes from extensive user research, the design cannot be fully validated until it is tested in a real work environment. Achieving this objective is not easy, but the potential impact of a more detailed and extensive study should be enough incentive for this project to be carried forward.

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